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MORPHOMETRY AND HYDROGRAPHY OF SOME NATURAL LAKES OF THE NORTH CAROLINA COASTAL PLAIN: THE BAY LAKE AS A MORPHOMETRIC TYPE

By David G. Frey

Department of Zoology, University of North Carolina
Chapel Hill, North Carolina

INTRODUCTION

In the summer of 1947 under the sponsorship of the North Carolina Wildlife Resources Commission studies were begun on a number of natural lakes in Bladen and Columbus counties.[1] It was realized at the outset from the examination of airplane photographs of the region and from reading the theories by various geologists concerning the origin of the Carolina bays that these lakes probably were of the same origin. It was not entirely unanticipated, therefore, to discover that the lakes are surprisingly alike in many of their morphometrical, chemical, and even biological characteristics, enough so to warrant considering the Bay Lake as a morphometric type. The present paper is concerned primarily with the distinctly morphometrical features of the lakes and to a lesser extent with some of the chemical characteristics of their water. It presumes to furnish a basis for further hydrobiological studies.

In the Atlantic Coastal Plain from Virginia to Georgia there are thousands of shallow, elliptical or ovoid depressions known as "Carolina Bays" from their first having been studied in the Carolinas where they are most abundant, and from their containing the various species of bay trees—*Magnolia virginiana*, *Gordonia lasianthus*, *Persea borbonia*, and *Persea palustris*. Strangely enough there have been very few published studies on these bays aside from geological investigations to determine their origin and botanical studies on their vegetation; but judging from the findings of Buell (1946) on Jerome Bay and current

[1] Other persons participating in the collection of the data here reported were Edward E. Hueske and T. Stuart Critcher of the N. C. Wildlife Resources Commission and A. Carter Broad of the Fisheries Research Institute of Morehead City. The Wildlife Resources Commission has also assisted in the publication of this paper by furnishing the plates of the illustrations.

investigations by the author on others, it seems likely from the nature of the sediments that many of these basins, perhaps all of them, at one time contained lakes. Nearly all such bodies of water have been extinguished by processes of filling in and lowering of the water table attendant on the incision of streams into the Coastal Plain, leaving behind the oval-shaped swamps so prominent from the air. But in North Carolina a small number of bay lakes still exist, with the main concentration in Bladen County in the vicinity of Elizabethtown.

As soon as the Carolina Bays were recognized by the geomorphologists, a number of theories were advanced to account for their origin, of which two are held most widely at present. Melton and Schriever (1932) proposed that all these depressions were formed by the impact of meteorites in the unconsolidated sediments of the Coastal Plain. As evidence accumulated the theory was modified in various ways, until in its present form it conceives of a large shower of meteorites striking the earth obliquely from a northwest direction, excavating the depressions not so much by the impact of the meteorites themselves or by their explosions on striking the earth as by the shock waves preceding them. (This whole subject is reviewed by Johnson, 1942.) Opposed to this theory is that of Johnson (1942), who conceived of the Coastal Plain depressions as having arisen from a complex of natural forces resulting from ground water, artesian water, solution, and wind action. The present paper does not attempt to decide what the most likely origin of these basins is, but merely to describe the present configuration of some of those still containing lakes and to consider some of the forces which have been active in producing them.

METHODS

From aerial photographs of the region made under the direction of the U. S. Department of Agriculture in 1938, working outlines of the lakes were traced. Actual surveying of the lakes was then completed with a plane table and a non-telescopic alidade. Stations (frequently cypress trees in shallow water close to shore) were established at convenient distances and were then incorporated into a triangulation grid with the plane table. A base line distance between two stations was measured with a standard 100-foot steel surveyor's tape.

As an outboard motor boat was run along ranges at a suitable relationship to each plane table station, soundings were made at convenient intervals of approximately 250 to 1000 feet, with a standard stadia rod, to the bottom of which was securely fastened a small tin can to enable the depth of water to be more accurately determined and to enable a sample of the uppermost sediments to be raised to the boat for examination. Data on the depth of water to the nearest tenth of a foot and the character of the bottom sediments were recorded at each position, which, after a suitable exchange of flag signals between boat and shore, was sighted on the range line with the alidade.

It was soon discovered that the major portion of these lakes was relatively flat, with most of the contour lines crowded close to shore. In order, therefore, to determine the bottom configuration more exactly, soundings were taken at

measured intervals of 50 or 100 feet, depending on the size of the lake, along numerous lines at right angles to the shore, extending from the edge of the water out to the central plain of the lake (Table 1).

In the laboratory the data from the field notebook were transferred to the plane table map, and contour lines at intervals of one foot were drawn by inspection. The areas of the lakes and of the various contour surfaces were measured with a K & E compensating planimeter. Volumes were then calculated by use of the established formula for this type of work, $V = \frac{h(a_1 + a_2 + \sqrt{a_1 \cdot a_2}}{3}$, where a_1 is the area of the upper contour surface, a_2 that of the lower, and h the vertical distance between them. For the lowermost portion, the formula for the volume of a cone was used, $V = \frac{h \cdot a}{3}$. Length of shoreline was determined with a standard map measurer. The shoreline development, which is the ratio of the actual length of the shoreline to that of the circumference of a circle with an area equal to that of the lake, denotes the irregularity of the shoreline and the departure of the lake from a circular shape. Volume development which is equal to $3 \times \frac{\text{mean depth}}{\text{maximum depth}}$ indicates the general configuration of the lake basin according to whether the ratio is greater than or less than unity.

TABLE 1

Number and intensity of soundings in each of the six bay lakes investigated

LAKE	NUMBER OF SOUNDINGS			
	From plane table	Measured from shore	Total	Per mi.[2] lake area
Jones	87	131	218	623
Salters	99	244	343	700
Singletary	119	324	443	498
White	274	266	540	323
Black	242	114	356	162
Waccamaw	257	245	502	36

Only three types of bottom sediments were found in contact with the water: 1) *sand*, usually fairly clean and coarse in shallow water, becoming finer and darker with organic matter away from shore, 2) *pulpy peat*, a soft homogeneous, black or slightly brownish organic sediment, often containing a very small proportion of sand, detectable by rubbing some of the material between the fingers, and 3) *fibrous peat*, a light yellowish-brown mass of softened and partially decomposed rootlets, twigs, and leaves, with larger pieces of wood mixed in. The boundary between sand and either of the two other types of deposits was fairly sharp. That between pulpy peat and fibrous peat was not always sharp, so that the arbitrary limits of these two deposits may be subject to some variation according to individual interpretation.

RELIABILITY OF RESULTS

Sometime after the summer of 1947 it was discovered that three of the lakes—White, Jones, and Salters—had been previously surveyed in the late twenties by Thorndike Saville, Chief Engineer of the Water Resources Division of the North Carolina Department of Conservation and Development. By means of standard traverse surveys outlines of the lakes were prepared from which the area and length of shoreline were determined. No hydrographic studies were made. A comparison of the results in Table 2 reveals a close correspondence between the two sets of surveys. With respect to area the maximum difference is just over two per cent, and with respect to length of shoreline four per cent. The similarity in the figures for White Lake is especially interesting, because the outline map of this lake had to be pieced together from two separate aerial photographs. Because of the greater ease in making a plane table survey based on an outline obtained from aerial photographs, it is gratifying to learn that this type of survey can be quite reliable for fairly large lakes as well as for small lakes.

TABLE 2

Comparison of area and length of shoreline determinations in two separate surveys

LAKE	AREA			SHORELINE		
	1947 survey	Traverse survey	Difference	1947 survey	Traverse survey	Difference
	acres	*acres*	*per cent*	*miles*	*miles*	*per cent*
Jones	224	227	1.4	2.19	2.27	3.7
Salters	315	322	2.2	2.70	2.73	1.1
White	1068	1065	0.3	4.77	4.58	4.0

In 1935 the Resettlement Administration in the process of developing Singletary and Jones lakes for recreational purposes determined the elevations of the lake surfaces[3] and prepared rough hydrographic maps, which agree in general with the ones reported in this paper. The accuracy of the maps presented in this report depends on how nearly the boat was on the range being worked at the time each sounding was sighted from the plane table. Since readjustments were frequently made in the boat's direction to correct for drift, using the stadia rod as a sighting device for making these adjustments, it is believed that most soundings were taken within 25 feet of the line being run. Allowing for the most acute angles sighted, it is probable that the true locations of each sounding is within 40 feet of where its position is plotted on the map. This difference is of little importance in the flat central plain of the lakes. The contour lines along shore where the gradient is steepest were located more accurately by measurement from shore. Hence, it is believed that the volume determinations from the contour maps are at least as accurate as the outline maps of the lakes.

[3] Surface elevations: Singletary 63 ft., Jones 73 ft. The elevations of the other lakes are probably less than that of Jones because of the general seaward slope of the Coastal Plain terraces.

GENERAL CONSIDERATIONS OF THE INDIVIDUAL LAKES

Jones Lake[3]

The smallest of the lakes investigated is one of the most attractive. Its dark colored water is virtually free of suspended matter, enabling a number 20-mesh plankton net to be towed for long distances without any appreciable decrease in efficiency.

Towards the southeast end where a natural sand beach occurs is a Colored Recreation Area, operated by the Department of Conservation and Development. No other cultural developments occur on the lake.

Jones Lake, as is typical of all the bay lakes, gives clear evidence of considerable fluctuation of water level during the past few hundred years. Along the east shore just north of the outlet, for example, is a row of cypress trees about 50 feet from shore, exactly paralleling the shore with 3 scallops. This represents an old shoreline, since the cypresses must get started on dry land. These trees are at present in 16 inches of water, which means that the lake level must have been approximately 16 inches lower at the time the trees became established than it is now. Although the trees are not very large, cores taken with an increment borer indicate they are approximately 400 years old. Along the deeper northwest shore are a few large isolated trees occurring in even deeper water, and hence presumably older, although not necessarily so. They give evidence of a lower water level.

Salters Lake

The least accessible of the lakes, Salters, probably has least reason for the average person visiting it. Fishing is poor, the shores of the lake are crowded everywhere with a dense, all but impenetrable tangle of shrubs and trees, and there are no natural sand beaches. There are no developments of any kind on the lake, except for a few boats which the Forest Service maintains for the use of the infrequent fishermen. The shoreline gives considerable evidence of somewhat recent expansion of the lake area.

Singletary Lake

Singletary boasts a greater length of natural sand beach than any of the other lakes of Bladen County. At the east end of the lake just below the outlet is a development begun by the Resettlement Administration and now operated by the Department of Conservation and Development as a group recreation camp. This is the only development on the lake.

The Resettlement Administration dredged out a channel in the outlet creek and constructed a spillway dam 160 yards from the original shoreline in the region of the sand rim. This provides a convenient reference point for observing fluctuations in lake level. On July 14, 1947, the lake level was 10 inches

[3] The diagrams of hydrography and distribution of bottom deposits and the morphometrical data for each lake at the end of the paper (Figs. 6–11, and Tables 8–13) should be referred to.

below the crest of the spillway, and on November 16, 1947, it was 4 inches above, giving an observed fluctuation of 14 inches. According to reports this is fairly typical of annual fluctuations in water level of all the Bladen County lakes.

Singletary Lake exhibits more filling in of the bay along the sides than do the others, yielding a body of water more elongated in shape than is the usual condition. As a result the shoreline development of Singletary is the largest of any of the lakes. The deepest water found in any of the lakes was near the southeast end of Singletary. The water of this lake contains a large amount of organic detritus which quickly coats anything placed in the water and clogs even a number 10-mesh plankton net so that its filtering efficiency is greatly reduced.

White Lake

White Lake derives its name from the clarity of its water and almost complete absence of color, a characteristic not shared by any of the other lakes. A white secchi disc is readily visible on the bottom, even in the deepest part of the lake. This feature has made the lake most desirable from a recreational standpoint, and has resulted in a number of resorts and many cottages being located along its shores.

The most plausible explanation for the lack of color is that of drainage. All the lakes except White Lake have their outlets somewhere in the southeastern to southwestern section, so that rainwater leeching through the bay vegetation and peat deposits at the northwest end must flow through the lake to leave the basin. In White Lake, on the other hand, the outlet is at the northwest end almost in the middle of the filled in portion of the bay, and hence the dark colored water from this region is drained away from the lake rather than through it. On November 15, 1947, for instance, after a rather heavy rain, the color of the water immediately adjacent to the northwest shore was as usual less than 10 parts per million, as measured with a USGS color set, whereas that of the outlet creek at the road bridge just outside the edge of the bay was 440 parts per million. At this same time there was a zone of colored water up to 100 yds. wide along the entire shore except at the northwest. The color of this zone ranged from 32 to 55, being darkest immediately adjacent to the shore.

According to reports White Lake is spring fed. Offshore about the middle of the northeast side are a number of round clean areas in a region where the sand is thinly covered with fine dark detritus. Careful soundings of these areas showed the centers about 8 inches lower than the edges, but the bottoms were hard, no bubbling as reported by other visitors could be observed through a water glass, and there was no detectable chemical evidence of any volume of water entering the lake through these depressions. Earlier in the year at a time of higher lake level and more favorable ground water conditions there might be visible evidence of inflowing water.

There is also a belief that some springs at the base of a cliff along the Cape Fear River within 3 miles of the lake are the result of an underground outlet from the lake, but there is no concrete evidence in the matter. The only known outlet is the small surface creek at the northwest end of the lake, which flows except in extremely dry periods.

Black Lake

Black Lake differs from the others in the indefiniteness of the margin of the bay in which it is situated. The others all have a distinctly oval outline, but that of Black Lake is quite irregular and in places appears to merge indistinguishably with neighboring bays. There are no natural sand beaches on the lake except at two small places along the southwest shore where the basin of Black Lake has cut across the sand rim of a smaller bay during its period of enlargement. At the southeast end of Black Lake are many small irregularities in the shoreline, with adjacent small coves being separated by narrow peninsulas of land often only a few feet wide, covered with typical bay shrubs and trees. This condition seems to represent a fairly recent expansion of the lake area through erosional activities. This is a phenomenon apparent in several of the other lakes as well, particularly Salters and parts of Singletary.

Black Lake, although the largest natural lake in Bladen County, is likewise the shallowest, with the maximum depth of water being just over seven feet near the southeast end.

An unknown quantity of water drains into Black Lake bay through a small inlet towards the northeast end. This is not readily detectable from the lake, but is apparent at a nearby road bridge. The outlet from the lake at the south end has no definite channel but rather spreads somewhat diffusely over and through the surface of the ground, resulting in a slow unidirectional drift of water through swampy land.

Black Lake is accessible only with difficulty by road and there is no cultural development of the lake.

Lake Waccamaw

Waccamaw, the largest of the lakes studied, is nevertheless smaller than the dimensions of five by seven miles claimed by the nearby inhabitants. The lake is more nearly three by five miles. The erroneous conception as to size dates back at least to the time of John Bartram, who reported in the diary of his journey in 1765–66, "... Wocoma lake ... is 8 miles long & 5 broad & about 12 foot deep & very shoal toward ye borders in some places ..." (Harper, 1942). The exaggeration of the horizontal dimensions does not apply to the vertical, since the maximum depth of the lake reported is substantially correct.

Waccamaw is the only bay lake examined thus far with sand completely around the shore. This has been brought about by a sand bar working across the northwest end and isolating the peat-filled portion which had formerly been in direct contact with the open water, as it still is in the other bay lakes. A similar alteration, although to a lesser degree, occurred at the southeast end of the lake. As a result there are just two types of bottom deposits—sand and pulpy peat—at the surface of the present lake basin.

The dark colored water is probably derived from the extensive swamp to the northeast of the lake which drains into the lake through Big Creek. The color of the water in this creek is much darker than that in the lake itself, where it has been observed to fluctuate considerably from one year to another (See the data of Aug. 23, 1947, in Table 14). Hubbs and Raney (1946), for instance,

reported that the lake when visited on March 30, 1941, had almost no perceptible color, yet a color averaging 160 ppm. was observed in the lake in 1947. These variations would considerably affect the rate of light penetration and the dependent photosynthesis. Fish from the creek are much darker in color than those from the lake, and the question arises as to whether or not there is a partial barrier here to the free exchange of individuals.

The greatest depth of water is not in the lake itself but in Big Creek within a relatively short distance of the lake. The creek bottom is separated from the lake by a sand bar sloping steeply on the creek side, covered by less than four feet of water at the deepest place. It is likely that the creek water below this sill can be effectively isolated from the lake, especially in spring and fall when its bottom temperature might be considerably below that of the lake.

At the outlet of Waccamaw is a low concrete spillway dam with a broad concrete apron, constructed some time ago to help regulate the water level of the lake. Several years ago when the dam washed out around the abutments, the lake level dropped approximately 2 feet, permitting the establishment of a new crop of cypresses in the shallow southeast shoals.

Except for a few widely scattered cottages, cultural development of the lake is confined to the high ground for several miles along the upper northeast side. At one low point in this region there is exposed an outcrop of the fossiliferous Duplin formation of Miocene age, overlying the dark phosphatic Cretaceous formation (Clark, 1912). Hence, one has here the somewhat novel experience of collecting tertiary marine fossils (corals, oysters, Crepidula, Pecten, Venus, sharks' teeth, etc.) from a fresh water lake. It is believed this calcareous Miocene formation plays a significant role in bringing the chemical reaction of Waccamaw water to neutrality, whereas in all the other lakes studied the water is very acid.

THE BAY LAKE AS A MORPHOMETRIC TYPE

A detailed comparison of the lakes and their respective bays reveals a number of interesting and significant similarities. Each lake is located in an oval area known as a "Carolina Bay," surrounded more or less by a rim of white sand which is most prominent towards the east and southeast sides. It is likely that these sharp outer limits of the bays represent the maximum size of the lakes at any time in their history. Furthermore, in all lakes except Black and Waccamaw the bay appears to be congruent with the drainage basin because of the lack of surface affluents. This means that except for an unknown quantity of water coming in below the surface of the ground, the water reaching the lake is largely that precipitated directly into the bay. The implications of this are a general scarcity of dissolved materials in the water, and, partly resulting from this low productivity and partly from a low level of allochthony, a very slow rate of sedimentation.

PATTERN OF FILLING IN

The areas of the bays vary from a minimun of 638 acres for Salters Lake to a maximum of 9801 acres for Wacamaw, but these acreages are no longer

the areas of the present day lakes. There has been a considerable amount of lake obliteration by the accumulation of peat deposits. These, as Buell (1939) has already pointed out. are best developed towards the northwest end of the bay, so that as the basin increases in ecological age the lake becomes displaced progressively towards the southeast end of the bay.

Except for Black Lake (see Table 3) there is an inverse relationship between the present size of the lake and the percentage of the original bay area which has been filled in. Thus, Jones Lake, the smallest, now occupies only 34 per cent of its bay, whereas Waccamaw, the largest, still fills 91 per cent of the area of its bay. It appears, however, that the small lakes are being obliterated more rapidly because of their original smaller size rather than because of a faster rate of areal decrease. The absolute areas of the various bays filled in appear to fall

TABLE 3

Areas of the bays and their contained lakes in Bladen and Columbus counties, N. C.

The bay area in all cases was taken to the outside edge of the typical bay vegetation where it meets the surrounding sand rim The bay area for each lake does not include that of any overlapping bays, as in the case of Salters, White, and Black (see Figures 1 and 2).

LAKE	AREA		PER CENT OF BAY OCCUPIED BY LAKE	ACRES OF BAY FILLED IN
	Bay	Lake		
	acres	*acres*		
Jones	667	224	33.6	443
Salters	638	315	49.4	323
Singletary	1022	569*	55.7	453
White	1496	1068	71.4	428
Black	2361	1418	60.0	943
Waccamaw	9801	8938	91.2	863

* The lake area does not include that of the artificial channel at the outlet.

readily into two groups. In the four smallest lakes (and likewise the four smallest bays) - Jones, Salters, Singletary, and White—slightly more than 400 acres of the original bays have been filled in. The figure for Salters Lake is less than this average by almost 100 acres, but at the time of the survey it was noted that Salters had more of an erosional than a depositional shoreline, indicating that perhaps the area of this lake has been enlarged from a previous minimum. The two largest lakes—Black and Waccamaw—have had twice as much of their original areas extinguished, but these figures are probably likewise misleading, in that there is evidence that both lakes have been enlarging their basins in recent time. One would ordinarily expect a larger lake, because of its greater length of shoreline and greater volume of shallow water, to exhibit a greater absolute areal decrease in unit time than a smaller lake.

The apparently constant rate of areal decrease in four of these lakes may be largely coincidental. There are many bays in the Coastal Plain (see Fig. 1) larger than those containing the lakes which have been completely filled with

vegetation and peat deposits. Either the rate of filling in these bays has been considerably faster than in the lake bays, perhaps varying with the original depth of the basin, or the filled-in bays represent older basins. Studies to determine the ages of a number of these basins have not yet been completed.

As the basins have been filled in, the lakes have not only been displaced towards the southeast, but two other phenomena have taken place concurrently: 1) the general shape of the lake (except for Singletary) has tended to become

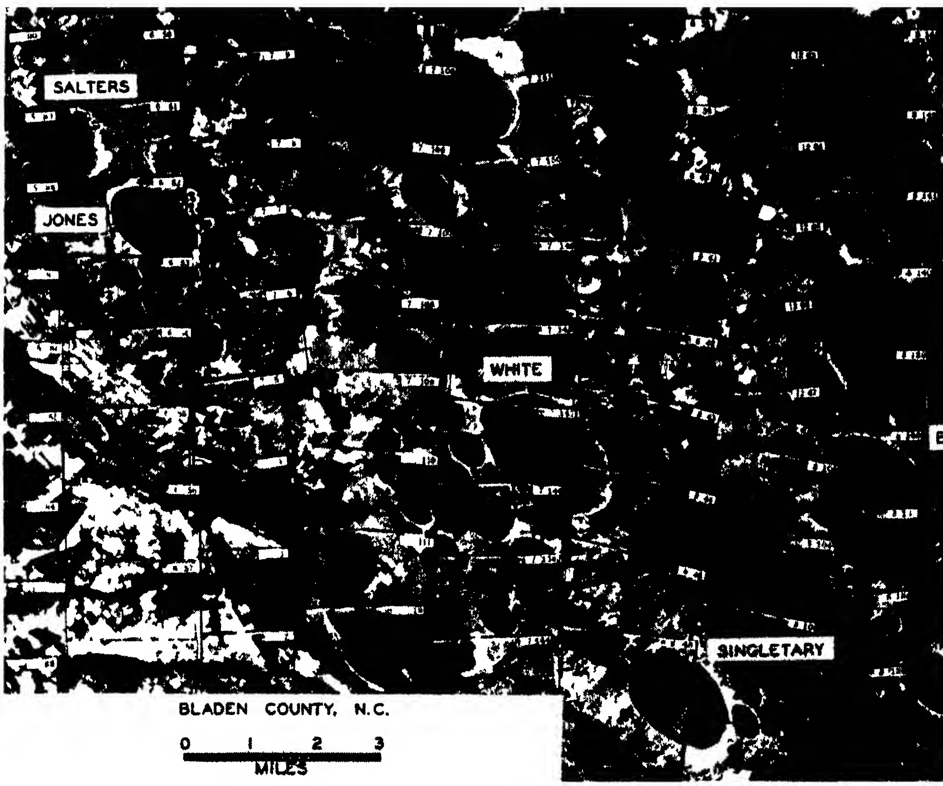

FIG. 1 Photographic mosaic of a portion of Bladen County, showing the location and general relationships of five bay lakes (USDA, Production and Marketing Administration.)

more nearly equidimensional than the original bay, and 2) the axis of elongation of the lake has rotated clockwise with reference to that of the respective bay (see Figs. 1 and 2).

Table 4 shows that the length-width ratios of the lakes are in all cases except Singletary less than those of the respective bays. Singletary Lake is relatively more elongate than its containing bay, a condition which has been brought about by means of a relatively greater degree of areal decrease along the northeast and southwest sides than at the northwest end. The greatest change in relative

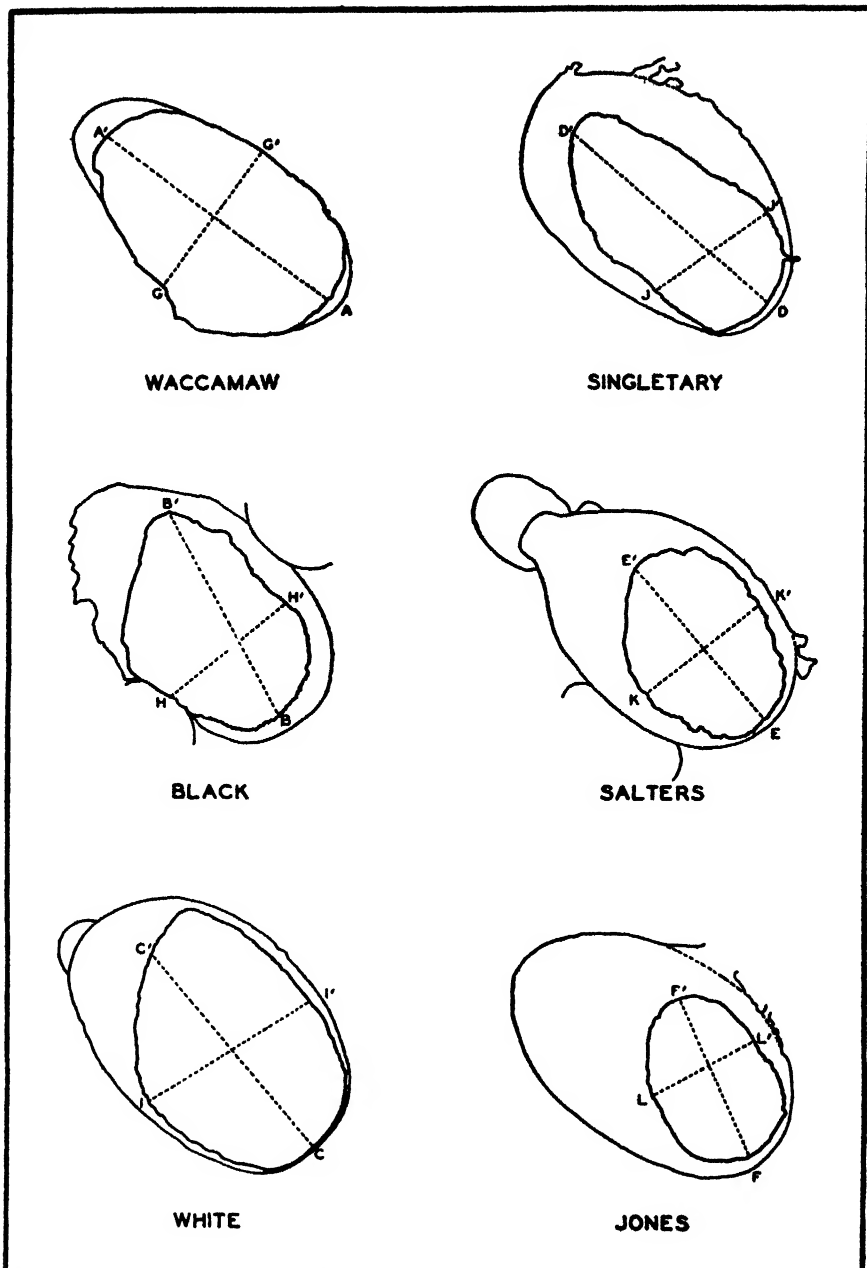

FIG. 2. Reduction of the bay lakes and their containing bays to the same absolute size to show the general pattern of orientation and filling in.

dimensions is in Waccamaw, where there has been filling in at both ends but none along the sides.

The directions of maximum elongation of the bays and lakes shown in the table are only approximate, since there was no means in the field of determining true north nor of determining the axes of elongation. Instead the angles listed were measured from the index maps of the aerial photographs of the region (see Fig. 1). Hence, these determinations are subject to any errors produced in assembling the photographic mosaic and to individual error in determining just what are the axes of the bays and lakes. The latter would probably be greatest in the case of Singletary, where the shape of the bay is somewhat anomalous.

The values obtained by these measurements are nevertheless instructive in that they emphasize first of all the marked similarity in orientation of the Carolina Bays. Except for Singletary, the axes of the bays do not differ by more than 6 degrees. Considering only the four lakes, Jones, Salters, White, and Black, which are much alike, the amount of clockwise rotation of the direction of elongation of the lakes respective to their bays has been from 22 to 28 degrees.

TABLE 4

Approximate directions of maximum elongation of the bays and their contained lakes, and ratios of maximum length to maximum width

LAKE	DEGREES WEST OF NORTH		LENGTH/WIDTH RATIO	
	Bay	Lake	Bay	Lake
Jones	57	25	1.57	1.44
Salters	54	26	1.61	1.39
Singletary	46	42	1.53	1.97
White	51	26	1.46	1.46
Black	51	28	1.59	1.48
Waccamaw	56	56	1.73	1.50

Such a marked similarity in "behavior" has certainly been in response to some widespread force, and one is inclined to think of the predominant winds from the northwest to southwest quadrant. Johnson (1942) places considerable emphasis on these winds in his theory concerning the origin of the bays, and Buell (1939) believes that they have been primarily responsible for the observed pattern of basin filling, most pronounced towards the protected northwest shore. Evidence will be presented later to show that these winds have been of great importance in producing much of the present basin configuration and distribution of bottom deposits. Extrapolating, it seems reasonable that the wind-generated currents in the early history of the bays were important in determining the original shape and nature of the basins.

The extent of areal decrease can be readily determined from photographs, but the extent of volume decrease can be determined only with great difficulty by borings taken along longitudinal and transverse ranges. It is not yet known, therefore, whether or not the largest lakes were also the deepest, nor is it known why lakes have persisted in these few bays but have completely disappeared in the surrounding bays, many of which have a greater surface area (see Fig. 1).

Whatever the original depths, the present lakes are all shallow. Waccamaw is not even a foot deeper than Salters, although its area is almost 30 times greater.

BOTTOM DEPOSITS

An ordinary survey can determine only the sediments at the surface of contact with the water, or those immediately beneath the surface. At the surface of these lakes are sand, a yellowish-brown fibrous peat, and a soft "greasy" pulpy peat (dygyttja?). Fibrous peat occurs only in a relatively narrow zone along the shore at the northwest end where the bays have been filling in most rapidly. Sand occurs elsewhere along the shore from the edge of the shore down the slope to the flat bottom of the lake. In Waccamaw, as previously stated, bars of sand have cut off the peat deposits at the northwest and southeast ends of the bay, resulting in sand all around the lake; no fibrous peat was found in the lake bottom. In all the other lakes except Jones the sand overlaps the fibrous peat offshore at the south end of the fibrous peat zone, and in White Lake at the north end as well (see Figs. 7b, 8b, 9b, and 10b). This makes it appear that either the sand is gradually working around the northwest shore and may eventually result in a condition like that in Waccamaw at the present time, or that the fibrous peat is a more recent deposit which has been laid down over the sand. The latter alternative is more likely, because in a number of instances only 0.1–0.2 foot of fibrous peat was found overlying sand.

The boundary between sand and pulpy peat is usually sharp and can readily be determined with a sounding pole. The sand, however, in some places extends beneath the pulpy peat, and can be felt beneath a thin layer of the softer material. The Black Creek formation, in which the Bladen County lakes are located, is predominantly sand, so that it is likely the bottoms of the original basins are sandy in nature. The boundary between fibrous peat and pulpy peat is to a certain extent a matter of individual opinion, since there is more or less of a gradual change from the greasy pulpy peat of the central plain to the yellowish fibrous peat at the northwest end.

A fourth deposit which appears to underlie the pulpy peat almost everywhere except immediately where it comes in contact with the sand is a light gray (sometimes brownish gray) silt or clay. This deposit was not found at the surface anywhere, although in White Lake it was at times covered by only a foot of organic sediments.

In Table 5 the percentage which each of the three surface sediments comprises of the total lake bottom as projected on the surface area of the lake is given. Since sand and pulpy peat are the two most extensive deposits, there is naturally an inverse relationship between them: when one declines in amount the other increases, and conversely. When the lakes are arranged in order of increasing size, a natural series appears to result. The largest lakes possess the greatest proportion of sand and the least of pulpy peat, whereas the smallest lakes have the least sand and the most pulpy peat. This results in direct relationships between the composition of the bottom sediments, the present size of the lakes, and the percentage of the original basins filled in by peat deposits.

As the lakes increase in ecological age (become smaller through filling in of their basins), the quantity of sand in the bottom decreases and of pulpy peat increases. When the lake area has been reduced to such an extent that wave action can no longer keep the shores towards the southeast end clear of the finer sediments, sand is then entirely eliminated from direct contact with the water. Such a condition was not observed in the lakes examined.

The fibrous peat along the protected northwest shore has probably resulted from the trunks, branches, and leaves of the vegetation growing near the shore and overhanging the water for distances up to 12 feet falling into the water and sinking to the bottom. The relative amount of this deposit in a lake may well be an indication as to the rate of filling in, inasmuch as areal decrease is most important at the northwest end.

TABLE 5

Percentage composition of the lake bottom deposits, measured in terms of the surface area of the lake

LAKE	PER CENT OF TOTAL		
	Sand	Pulpy peat	Fibrous peat
Jones	21	71	4
Salters	26	59	15
Singletary	43	49	8
White	44	52	4
Black	48	45	7
Waccamaw	64	36	0

MORPHOMETRY OF PRESENT LAKE BASINS

Although the configuration of the original lake basins cannot readily be determined, that of the portions still occupied by water can be ascertained by making a sufficient number of soundings. For any basin the existing configuration is the resultant of all the erosional and depositional processes which have been operating since the basin was formed.

The six lakes studied are similar in their morphometric characteristics, exhibiting progressive variations which appear to be a function of the size of the lake. The lakes are all somewhat saucer-shaped, with most of the contours being relatively close to shore, and the central plain being a remarkably flat area, sometimes varying not more than one-half foot in depth for 2000 yards or more. It is not surprising, therefore, to find that the volume development ratios are all greater than 2, except in the case of Singletary Lake, showing a wide departure from a conical shape.'

It is impossible to ascertain without making detailed borings what the depths of the original basins were, but it is interesting that even with the different rates of sedimentation which have probably taken place, the present depths of the lakes are very much alike. The lakes are all shallow, with maximum depths ranging from 7.1 ft. in Black to 11.8 ft. in Singletary, and mean depths from 5.3 ft. in Black to 7.6 in Waccamaw. There is a tendency, best developed in Single-

tary, White, and Black lakes, for the deepest water to be located close to the southeast end of the lake (see Figs. 8a, 9a, and 10a).

When the longitudinal and transverse sections of the lakes are examined (Fig. 3) it is apparent that the lakes have mature profiles, at least along the southeast shore. In all the lakes within 50 feet of the shoreline there is an initial drop of from 1.1–2.0 ft. which is produced by the smaller abundant waves against the shore. Then there follows a wave-built terrace, whose width is roughly proportional to the length of the lake. In Waccamaw, for example, the southeast terrace extends almost 1500 ft. from shore, in Black Lake 400 ft., and so on down to Jones Lake, which has a gradual slope from the edge of the water to the central plain with no terrace at all. White Lake does not follow this relationship, in that on the basis of length of lake, its terrace should be midway in size between those of Black and Singletary, whereas it is actually only about 50 ft. wide.

The presence of these terraces indicates that the waves against the southeast shores are strong and have been in operation for considerable periods of time. But since the length of each terrace is related to the length of the lake rather than the length of the containing bay, it is also likely that the terraces are equilibrium phenomena, which are altered as the dimensions of the lake are altered.

At the northwest end of the lakes there are no terraces. Here, where the dense growth of bay vegetation comes to the edge of the water, there are depths up to 5 feet at the water's edge. No influence of the wind is evident along this shore. Of all the lakes Singletary shows the most gradual rise in the bottom from the deepest place at the southeast end to the northwest shore, as a consequence of which it has the smallest volume development ratio.

The southwest and northeast shores are somewhat similar in profile in the three largest lakes, but in the three smallest lakes there is a marked asymmetry, with the average slope of the southwest shore tending to be steeper than that of the northeast. Waccamaw shows two terraces along the southwest shore and one broad terrace along the northeast shore, which has a number of irregularities in it. Black Lake exhibits a small terrace towards the southwest, and what might be considered a rather extensive deep water terrace towards the northeast. Although the level of this latter terrace is little above that of the central plain of the lake, it is composed entirely of sand rather than of pulpy peat. White Lake, which has the most nearly regular basin of any of the lakes examined, cannot be said to have any lateral terraces. The three smallest lakes may or may not have traces of terraces at the southwest, but all of them—even Jones—have narrow terraces at various depths along the northeast shore. Thus for the particular places in the lakes where the profiles were made, in Singletary the terraces occur at depths of 2.7–3.4 ft., 4.0–4.4 ft., and 5.5–6.0 ft., in Salters from 3.0–3.4 ft., and in Jones from 3.6–4.1 ft. The transverse sections show that even in the two latter lakes there is a tendency towards development of multiple terraces.

In the only other published study on a Carolina Bay, Buell (1946) likewise observed the development of multiple terraces along the northeast and southeast sides in Jerome Bay, a completely filled-in bay in the northwest corner of Bladen County. With a Davis peat borer he penetrated the sediments of the

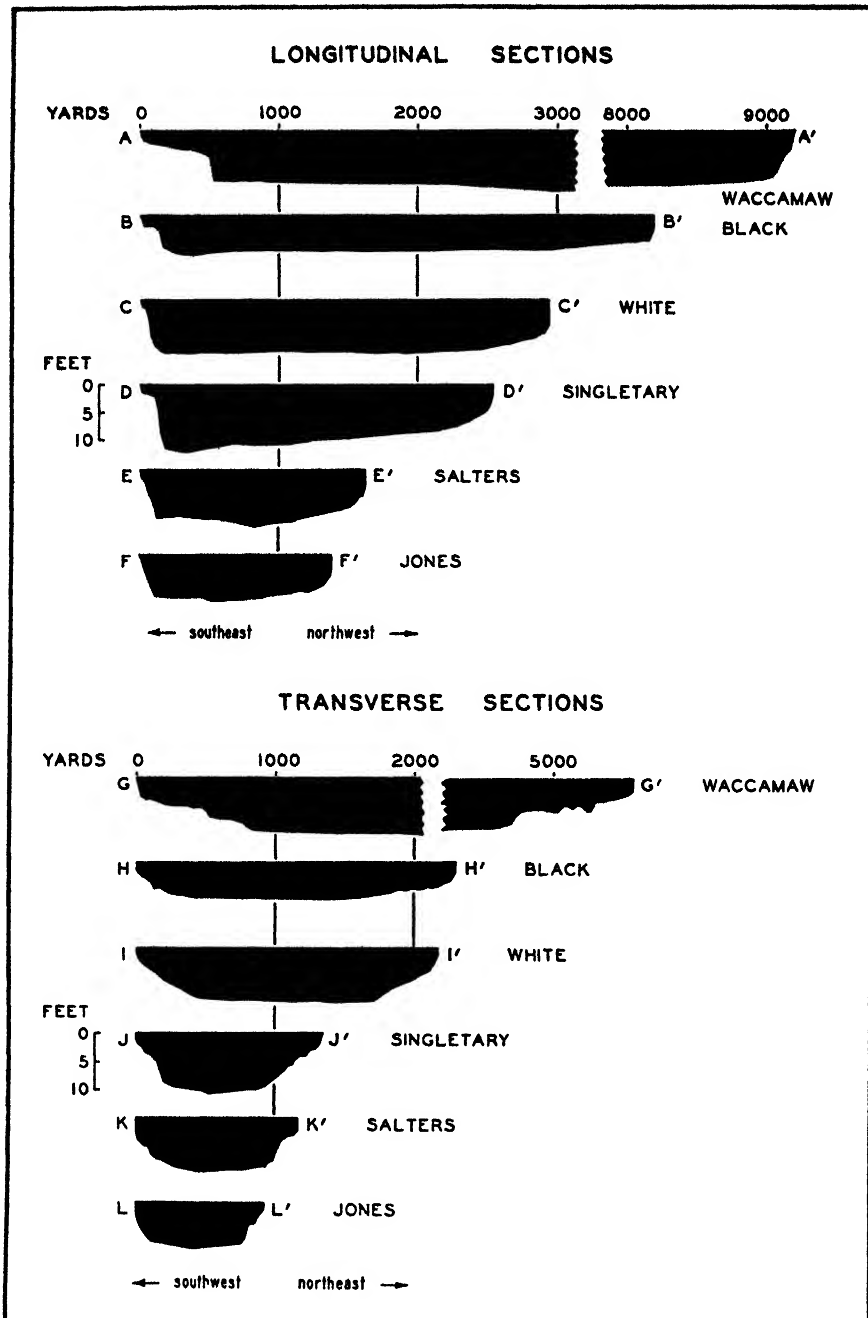

FIG. 3. Transverse and longitudinal profiles of the bay lakes. Note that the depths are greatly exaggerated with respect to the horizontal dimensions. The locations of these particular sections are shown in Fig. 2.

bay to the underlying sand, which was assumed to be the limits of the original lake basin. His study, however, is not strictly comparable to the present one, since from his profile diagrams it cannot be determined where the bottom was located at any particular stage of the lake, nor consequently how many of the terraces were exposed simultaneously.

It is difficult to conceive how along a single exposed shore a number of terraces might be formed simultaneously. Although the evidence from the terraces at the southeastern end is that these structures are in equilibrium with the wave action and hence can be modified in dimensions as the force of the wave action changes, it might nevertheless be true that the terraces along the northeast shore, not being subject to such strong waves, are more nearly permanent. They can possibly represent previous low water stages of the lakes. In each of the lakes, for example, there are cypress trees growing away from shore in water of varying depth, sometimes as deep as 4 feet. Whatever the depth at which these trees now occur, the lake bottom must have been exposed in order for the trees to get started, since cypress seeds cannot germinate and take root underneath the water. The fact that the terraces are best developed along the southeast and northeast shores indicates that the winds of greatest effect come from the northwest to southwest directions, as previously indicated.

At first consideration it seems anomalous that the rate of filling has been most rapid at the northwest end where the deepest water now occurs, and least of all at the southeast where the shallowest water of the entire lake is located. The northwest end of the original basin was undoubtedly shallow enough at one time so that vegetation could easily become established along this protected shore. Now, however, the water is so deep along this shore that only with extreme fluctuations in water level can new cypresses become rooted. The accumulation of fibrous peat offshore must be an extremely slow process.

New crops of cypresses do get started on the southeast and south shoals at the present time. A dense stand in White Lake in this region dates back about 130 years, presumably to the time when the lake level is reported to have been lowered about 2 feet by the operation of a sawmill at the east end, and in Waccamaw there is a more recent crop of new trees only a few years old, as previously indicated. No doubt there have been other similar stands in the long histories of these lakes, but for some reason— perhaps the strong wave action along this shore—the trees were eventually all killed without contributing materially to the advance of the shore into the lake. Thus the same forces which made the terraces and provided the best location for the establishment of new generations of trees are also responsible for keeping the trees off these shoal areas.

The aerial photographs of Lake Waccamaw are remarkable in that they were taken under conditions of water transparency and angle of sunlight enabling certain details of the terraces to be distinguished. The broad terrace at the southeast end is quite clearly visible, those to the northeast and southwest are a little less so, and each terrace has irregularities in it, which are in the nature of sand ridges formed by wave and current action.

At the southeast end of the lake for a distance of 6000 feet along shore are a

series of small ridges paralleling the shore and extending offshore for a distance of 1000 feet. These sand waves average 45 feet from crest to crest, but they are largest and farthest apart closest to shore where the currents are strongest.

Extending along shore for 11,000 feet from this zone towards the outlet of the lake are a series of ridges projecting out from shore at an angle towards the northwest (Fig. 4). They are not strictly parallel, because their direction of elongation tends to shift clockwise with increasing distance from the southeast end. These ridges are visible up to 1500 feet offshore, and in the area just north of the

FIG. 4. Aerial photograph of a portion of the south end of Lake Waccamaw, showing the prominent sand ridges in the terrace along the shore. (USDA, Production and Marketing Administration.)

outlet there is another more diffuse and irregular group of similar ridges extending up to 2500 feet from shore.

Along the northeast side of the lake are other sand ridges, which are quite irregular in shape, and trend in a direction slightly east of south. They are visible on the photographs up to 2500 feet from shore. The irregularities in the northeast terrace of Lake Waccamaw shown in Fig. 3 undoubtedly are produced by some of these ridges. No attempt was made to chart any of these bars and ridges on the hydrographic map.

Such extensive irregularities in the sandy bottom of Waccamaw indicate the force of the currents which can be generated by the winds. The ridges parallel to shore at the southeast end seem to indicate that the winds of maximum effect are from the northwest. Westerly and northwesterly waves reflected from the northeast shore have built up the irregular ridges trending southward. The

surface return of water at the southeast end appears to have been mainly clockwise, resulting in the extensive series of ridges along the south and southwest shore. If there is any general circulation of the lake generated by the winds, all evidence indicates that it is strongest in a clockwise direction. None of the

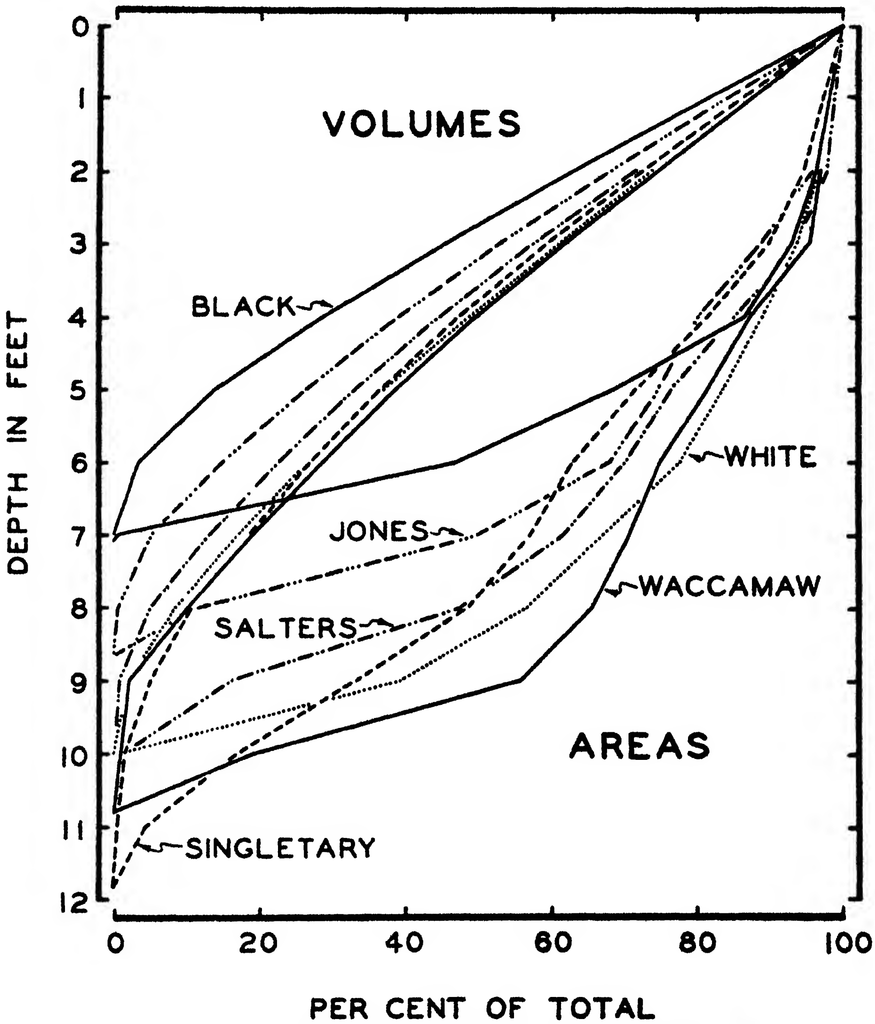

FIG. 5. Area and volume hypsographic curves for the bay lakes

other lakes, presumably because of their small size, exhibit similar sand bars, with the possible exception of Black Lake.

In biological studies on lakes it is frequently necessary to be able to determine the surface area at a particular depth, or the volume of water below a certain depth. Both of these types of data can be readily determined from the tables at the end of this report and from the area and volume hypsographic curves in Fig. 5. The area curves again emphasize the steep-sided, flat-bottomed shape

of the basins, and also demonstrate how little a fluctuation in water level of a foot or two would change the surface area of the lakes.

CHEMISTRY AND PHYSICS OF THE LAKE WATERS

Two vertical series of water samples and temperature measurements were obtained from each lake during the time it was being surveyed, and additional miscellaneous observations were made on the lakes in the fall of 1947 and the summer of 1948. The derived data, although inadequate to characterize these lakes completely, physically and chemically, do indicate a number of significant features concerning them.

Measurements of transparency were made with a standard 20-cm. secchi disc. Temperatures at the various levels were obtained by means of GM reversing thermometers. Water samples were obtained with a Kemmerer water bottle.

TABLE 6

Summary of average physical and chemical conditions in the six bay lakes during the summer and fall of 1947

LAKE	NUMBER OF SAMPLES	DISC	COLOR	pH	ACIDITY AND ALKALINITY: ml. N/44 NaOH per liter	ACIDITY AND ALKALINITY: ml. N/44 H_2SO_4 per liter	DISSOLVED O_2	
		ft.	*ppm.*				*ppm.*	*per cent*
Jones	9	2.4	297	4.34	10.7	3.0	5.7	70
Salters	7	1.8	299	4.49	9.9	3.2	6.0	71
Singletary	10	2.5	168	4.50	6.7	2.4	6.6	81
White	8	11+	<10	4.92	3.5	1.6	6.7	84
Black	6	1.8	182	4.40	7.6	1.9	6.4	82
Waccamaw	8	4.4	160	6.95	3.5	9.2	5.2	70

For oxygen determinations the "rapid sample-blank modification" of the Winkler method, as recommended by Ellis, Westfall, and Ellis (1946), was used. Saturation values were determined with the aid of the nomogram presented by Rawson (1944). Total acidity and alkalinity were determined by titrating separate 100 ml. samples with N/44 NaOH to the phenolphthalein endpoint, or with N/44 H_2SO_4 to the methyl orange endpoint. Ordinarily these results would be reported as parts per million of free carbon dioxide and bound carbon dioxide, but for reasons given later they cannot be so reported in the present instances. Hydrogen ion concentration was measured with a Coleman pH electrometer, Model 3D, standardized against an Hydrion buffer of value 5.6 ± 0.05. Color, expressed as parts per million of potassium chloroplatinate, was measured by visual comparison with a standard U. S. Geological Survey color set.

Table 6 summarizes the physical and chemical conditions in the lakes during the brief periods of observation, and Table 14 at the end of the paper presents the results of the individual series of analyses. It is apparent from these data that the penetration of light into the water, as measured by a secchi disc, is rather

low except in White Lake, where the disc was readily visible at the maximum depth.

One of the principal determinants of light penetration is the color of the water, which here varies from the almost colorless condition of White Lake to the strongly tea-colored water of Jones and Salters. The other three lakes exhibit an intermediate condition. Inspection of the table, however, shows that the correlation between color and transparency is only an approximate one, and the reason for this is that the amount of particulate matter (seston), both living and non-living, in the water, is the second important determinant of light penetration. Singletary, Black, and Salters lakes have greater quantities of non-living organic seston than the other lakes, which makes it possible, for example, for Jones and Singletary to have approximately the same transparency, even though the color of the former is almost twice as great. The evidence for the dark color being derived from the leaching of the vegetation and peat deposits around the margins of the lakes, and for the proposed explanation of the clarity of White Lake—that of drainage pattern—has already been discussed. Because of the pronounced color, all the lakes except White Lake would be considered dystrophic. Dissolved color accentuates biological and thermal stratification through its affect on light absorption, and these in turn tend to make the chemical stratification sharper than in a clear water lake.

The chemical reaction of most natural waters occurs within the pH range 6.0–8.5. If the acidity is great enough to lower the pH below 5.5, the acid condition can begin to affect biological processes and the lake is no longer harmonic: it is considered to be acidotrophic (Naumann, 1932). All the bay lakes here described, except Waccamaw, are strongly acidotrophic, with the average pH ranging from 4.34 in Jones to 4.92 in White. The higher pH (6.95) in Waccamaw is believed to result from the solution of lime and other minerals from the outcrops of the calcareous Duplin formation and of the older Cretaceous formation along the northeast shore (Clark, 1912).

Acidity in natural waters is usually caused by the carbon dioxide complex and/or organic acids such as humic acids dissolved in the water. Both of these can be eliminated as the primary cause of acidity in these lakes. If the pH of a fresh sample of water is determined, and then, after any free carbon dioxide present has been removed by thorough aeration, the pH is measured a second time, there is no consistent observable change in the pH value, showing that free carbon dioxide if present is not materially affecting the acidity. Even boiling a sample of water did not significantly alter the chemical reaction. That organic acids, likewise, are not the cause of the high acidity is demonstrated by the fact that the pH of White Lake is almost as low as that of the other Bladen County lakes, even though its color is very much less. Color of the type found in swampy lakes, it might be added, is primarily caused by these organic acids.

Table 6 demonstrates further that relatively small quantities of standard alkali are required to adjust the reaction of these lake waters to the phenolphthalein endpoint, and that likewise only small quantities of standard acid are needed to increase the acidity to the methyl orange endpoint. This indicates

two conditions: 1) that the substances producing the acidity although rather intense in their activity are present only in small quantities, and 2) that there is relatively little buffer capacity in the water to resist changes in pH. In most natural waters the figures for N/44 NaOH in Table 6 would be listed as parts per million of free carbon dioxide, and half the values of the N/44 H_2SO_4 figures as bound carbon dioxide, the latter indicating roughly the total amount of calcium and magnesium present.

Frequently samples of bottom sediments brought to the surface had a faint odor of hydrogen sulphide, even though the water is apparently well aerated at all times. This suggested that perhaps free sulphuric acid might be the cause of the low pH, since it is known (see Ruttner, 1940, for example, or any textbook in bacteriology) that the colorless and red sulphur bacteria in lakes obtain their energy from hydrogen sulphide, with the ultimate release of sulphuric acid, which diffuses into the surrounding medium. Ordinarily this acid would react with various metallic ions in the water, but where the water is poor in dissolved minerals, some free acid might be expected.

Presumptive evidence that sulphuric acid produces the observed acidity is available from two sources. In the summer of 1947 Mr. Robert E. Short (1948) of North Carolina State College made chemical analyses on the bottom sediments of several lakes as part of a project supported by the North Carolina Wildlife Resources Commission. The materials to be analyzed were first extracted from the sample with a weak sodium acetate solution according to standardized procedures of soil chemistry. Then the approximate concentrations of sulphates were determined turbidimetrically, using barium chloride to precipitate the sulphate (Spurway, 1944). This method gives only the extractable sulphates rather than the total sulphates in the sediments.

According to these analyses the extractable sulphates in the bottom deposits of the four lakes investigated—Jones, Salters, Singletary, and White—are high, ranging up to 800 ppm. Only two samples out of the 22 analyzed contained less than 100 ppm., and the simple numerical average for all the samples was 360 ppm. Of the various ions tested for, sulphate was present in greatest concentration, and even allowing for considerable error in the method, there would still be an abundance of sulphates in the bottom deposits.

In the summer of 1948 Mr. Howard T. Odum ran some analyses on bottom sediments from Singletary Lake and water samples from several of the lakes.[4] The sulphate content of the water in White, Jones, Salters, and Waccamaw varied from 6.1 ppm. in Waccamaw to 7.9 ppm. in White. Because of certain errors which developed in the benzidine method employed, it is felt these results are only approximate, although of the correct general magnitude. Assuming that these results are substantially correct, that all the sulphate present is in the form of sulphuric acid, and that the acid is completely dissociated, the pH of a solution with 7 ppm. of sulphate would be 3.8, which is reasonable considering

[4] The work of H. T. Odum here reported was sponsored by a research grant to the author in 1948, Project C-50, from the Carnegie Foundation for the Advancement of Teaching.

the fact that the other substances present in the water would modify the chemical reaction.

Instances of low pH resulting from free sulphuric acid are reported in the literature. Yoshimura (1934) investigating Kata-numa with a minimum pH of 1.4 found 474 milligrams per liter of sulphate ions. Ohle (1934) reported that the Tonteich at Reinbeck contains significant quantities of sulphuric acid, but pointed out that an unusually high sulphate concentration is not necessary in a minerogenous acidotrophic lake, for example Pinnsee. Uéno (1934) reported that Onuma-ike had pH values of 2.8 to 3.8 over a five-year period. At one time he found the water contained 92 milligrams of sulphuric acid per liter.

These instances all occur either in regions of volcanic activity or in regions of iron pyrites oxidation. The North Carolina Coastal Plain is negative in both these respects. If the acidotrophy of this region is shown by additional work to result from sulphuric acid, it is likely that biological activity will have been the source.

The dissolved oxygen content of the lake waters never approached saturation, even in the surface waters. The particular analyses made showed White, Singletary, and Black lakes forming one group with approximately 80 per cent of saturation, the other three a second group at approximately 70 per cent. On the basis of biological productivity it was surprising for Waccamaw to have a lower average oxygen content than Black Lake, for example. The reasons for this are not known, since many factors would have to be studied concurrently to determine the controls of the oxygen levels at any particular time.

With the lakes as shallow as they are there is, of course, no permanent summer stratification. The chemical conditions from top to bottom may change over relatively short periods of time, depending on rainfall, photosynthesis, wind action, etc. Yet during bright, calm days steep microthermoclines can develop at the surface, temporarily cutting off the lower water from contact with the air. Such stratification, however, can be quite readily dispelled by the violent convectional squalls which often follow such conditions in the summer. In Black Lake on September 4, 1947, for example, the surface water temperature was 34.9°C, at one foot almost the same, and at 2 feet 31.0°C. A temperature difference of 5.5 degrees existed at this time between the surface and three feet. Surface conditions in Waccamaw on August 18 were almost as severe, with the temperature at the surface being 34.0° and at 3 feet 29.5°. The greatest temperature gradient found was in Salters Lake on June 30, 1947, with a temperature change of 5.7° over a vertical distance of 19 inches. The surface temperature at this time was 35.0°C. The examples quoted represent extreme conditions. Usually the temperature differences between surface and bottom were less than one degree centigrade.

Of the several chemical substances analyzed, only oxygen showed any consistent stratification. The tendency was for the per cent saturation to decline slightly with increasing depth, indicating that maximum oxygen addition through photosynthesis and agitation was occurring at or near the surface. In White Lake, however, the greatest concentrations of oxygen were in the bottom water,

which may well have resulted from photosynthesis by the higher plants growing on the bottom. White Lake was the only lake with rooted aquatics in deep water.

A few analyses were made by Odum on the amount of CaO in the lake waters, the total dissolved substances, and the loss on ignition. These data, summarized in Table 7, are subject to rather large errors and hence are only preliminary. The analysis of dissolved matter, for example, was made on 200 ml. samples, whereas with such small quantities of dissolved matter much larger samples should be used to reduce the relative magnitude of instrument errors. Calcium determinations were likewise made on 200 ml. samples, but here the quantities present are so small that errors up to several hundred per cent would not appreciably change the relative magnitude of the results. The general reliability of the latter results is evidenced by the small quantities of standard acid required to bring the reaction of these waters to the methyl orange end-point (Table 6).

TABLE 7

Analysis of calcium and dissolved matter in the water of four bay lakes

LAKE	CaO	DISSOLVED MATTER		
		Total solids	Loss on ignition	Inorganic residue
	ppm.	*ppm*	*ppm.*	*ppm.*
White	1.8	34.0	14.0	20.0
Jones	1.8	55.5	41.0	14.5
Singletary	2.1	53.5	39.0	14.5
Waccamaw	4.1	90.5	36.0	64.5

The quantities of calcium found in these lakes are very small. According to the system established by Naumann (1932) the lakes would be considered strongly oligotypic for calcium. In a study of 358 lakes in northern Wisconsin, Juday, Birge, and Meloche (1938) found that 21 per cent had a calcium content of less than 1 mg./l., and another 15 per cent 1.0–1.9 mg./l. This latter group would correspond to the North Carolina lakes, except for Waccamaw, which has a somewhat higher calcium content of 2.9 mg./l. To a considerable extent dystrophy develops only in regions low in calcium and magnesium, because these ions when abundant precipitate out the humic acids as humates, thereby preventing the accumulation of excessive color.

Loss on ignition, representing the dissolved organic matter, shows an expected correlation with the colors of the lake listed in Table 6. The inorganic residue in White, Jones, and Singletary is 20 parts per million or less, that in Waccamaw is three to four times greater. This agrees with the finding of a higher pH and a greater titratable alkalinity to methyl orange in Waccamaw than in the other lakes.

BIOTA

A separate report on the biota of these lakes will be presented later. Preliminary reports on the fishes (Hueske, 1948) and the benthos of Waccamaw (Frey, 1948b) have already appeared. A brief summary of these shows that in spite of the rather high acidity there is a rather good representation of organisms in the lakes. A total of 27 species of fishes were collected from the lakes. Waccamaw with 23 species had the greatest individual total, then followed White with 16, Jones with 13, Salters and Singletary with 12 each, and Black with 10 species. The lists contain a high proportion of predacious species, which, according to Hubbs and Raney (1946), explains the high rate of endemism in Waccamaw, where there were found three new species of *Fundulus*, *Boleosoma*, and *Menidia*, and possibly a new species of *Notropis* (described by Fowler). The fishes from the other lakes have not yet been sufficiently studied to determine whether or not evolution had proceeded along parallel lines in them.

The preliminary report on the benthos of Waccamaw showed an average of 579 organisms per square meter of bottom. The three groups of organisms most abundant were molluscs, 208 per square meter; two species of Tubificidae and one of Lumbriculidae, 179; and insects, 160, with *Hexagenia* nymphs being most abundant. The more acid lakes have smaller numbers of bottom organisms, particularly mollusca. In fact the only mollusc occurring in the acid Bladen County lakes is *Ferrissia hendersoni* Walker.

All lakes, except White, have a fairly good representation in the zooplankton of cladocera, copepods, and rotifers, but generally very little phytoplankton, as is to be expected in dystrophic lakes. Coker (1938) has already called attention to the fact that the plankton of White Lake is lacking in cladocera. Salters Lake was the only one with significant quantities of phytoplankton. Both in the summers of 1947 and 1948 *Asterionella* was abundant.

SUMMARY

The six lakes studied in the North Carolina Coastal Plain all conform to a common pattern, with differences resulting chiefly from differences in size of the basins. The lakes are saucer-shaped with regular outlines. Their single-depression basins are nowhere more than 12 feet deep, and the average depth varies from 5.3 to 7.6 feet.

Evidence from the pattern of filling, the profiles of slopes along the various shores, particularly the well developed terrace at the southeast end and the less well developed terraces along the northeast shore, the pattern of surface irregularities in the Waccamaw terraces, and the distribution of the bottom deposits all substantiate the marked influence of the westerly winds in controlling the morphometry and hydrography of the present basins, and presumably helping to shape the original basins.

The lakes tend to be dystrophic because of the swampy and peaty nature of their surroundings, but White Lake is colorless as a result of a difference in drainage pattern. The lakes tend to be strongly acidotrophic, with available evi-

dence indicating that sulphuric acid is very likely responsible for the low pH. The water of Waccamaw comes in contact with geological formations other than clean sand, from which it dissolves sufficient materials to raise its chemical reaction to neutrality. All the lakes are strongly oligotypic for calcium and have only small quantities of materials in solution. Presumably the basic pattern of production is oligotrophy, although no analyses on phosphorus and nitrogen are here reported.

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TABLE 8

JONES LAKE

Bladen County, N. C. 36°41′N, 78°36′W.

Area	224 acres	Maximum length	1420 yd., 0.80 mi.
Volume	707,100 yd.^{3}	Length shoreline	3860 yd., 2.19 mi.
Maximum depth	8.7 ft.	Shoreline development	1.05
Mean depth	6.1 ft.	Volume development	2.10
		Number of soundings	218

DEPTH	AREA		STRATUM	VOLUME	
	Acres	Per cent of total		Yd.^{3} × 10^6	Per cent of total
feet			*feet*		
0	224	100.0	0–2	0.71	32.0
2	214	95.5	2–3	0.33	15.1
3	198	88.4	3–4	0.31	13.9
4	181	80.8	4–5	0.28	12.7
5	167	74.5	5–6	0.26	11.7
6	152	67.8	6–7	0.21	9.6
7	111	49.5	7–8	0.10	4.7
8	26	11.6	8–8.7	0.01	0.4
Total				2.21	100.1

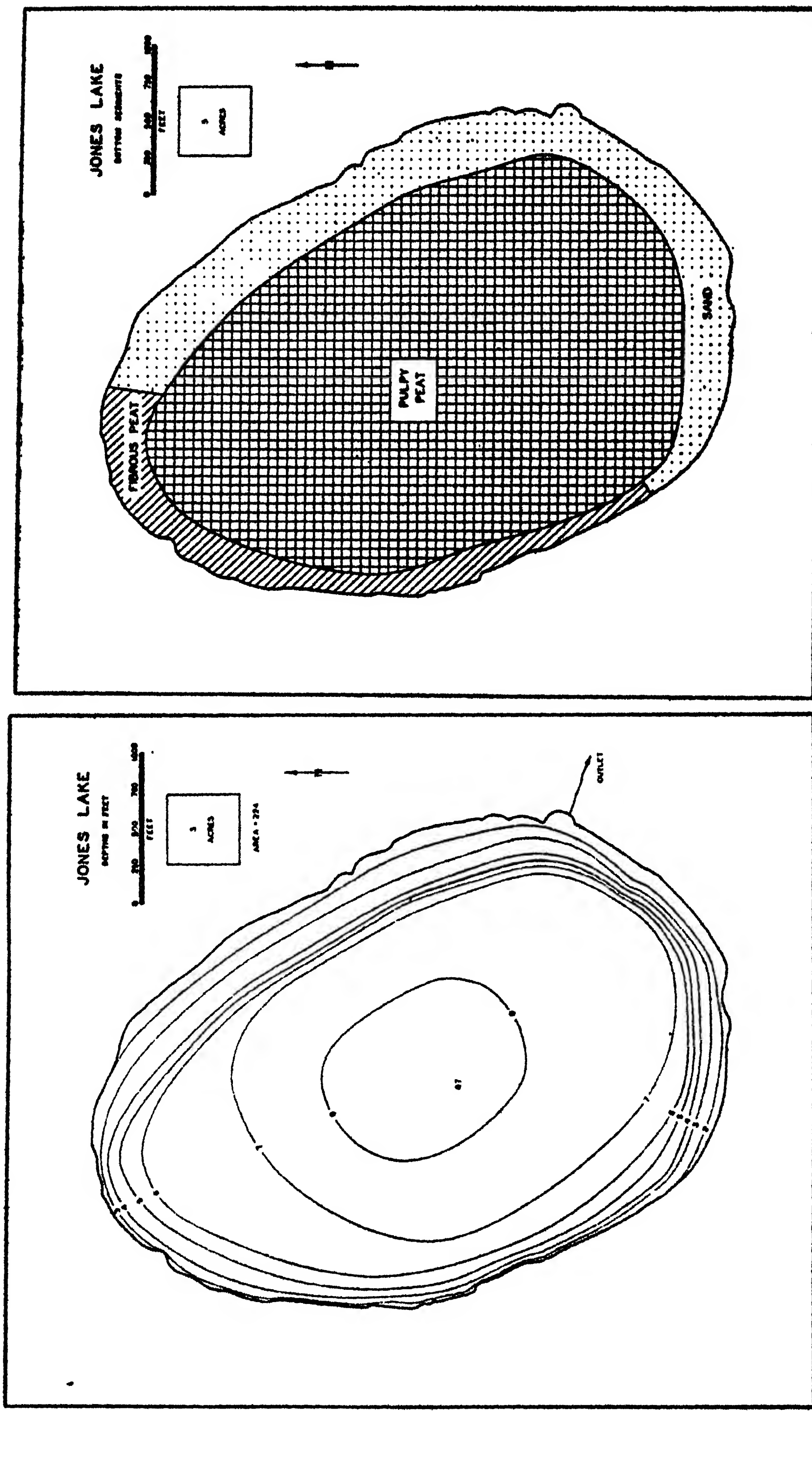
TABLE 9

SALTERS LAKE

Bladen County, N. C. 36°42′N, 78°38′W.

Area	315 acres	Maximum length	1660 yd., 0.94 mi.
Volume	3,520,200 yd.^{3}	Length shoreline	4760 yd., 2.70 mi.
Maximum depth	10.1 ft.	Shoreline development	1.09
Mean depth	6.9 ft.	Volume development	2.05
		Number of soundings	343

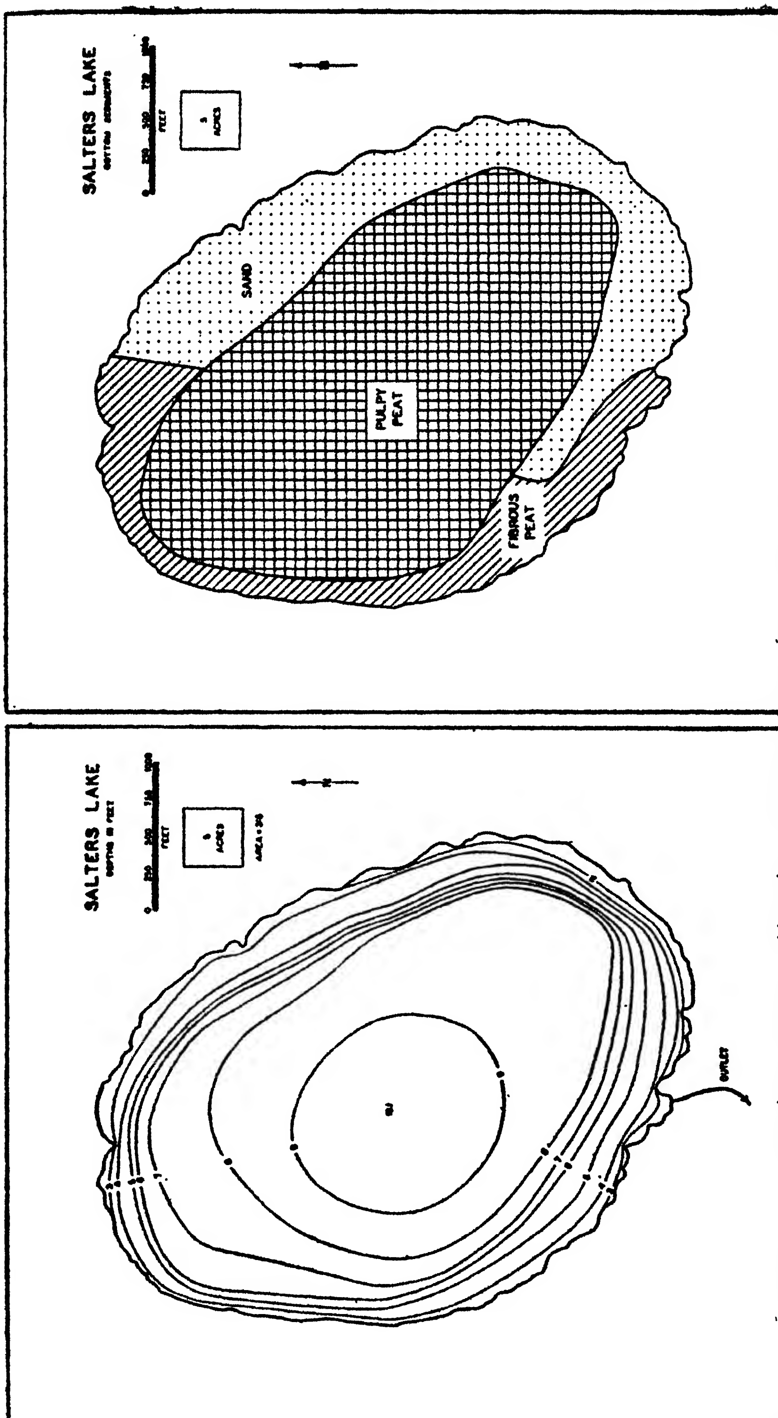
DEPTH	AREA		STRATUM	VOLUME	
	Acres	Per cent of total		Yd.^{3} × 10^6	Per cent of total
feet			*feet*		
0	315	100.0	0–2	1.01	28.6
2	309	98.1	2–3	0.49	13.8
3	295	93.6	3–4	0.45	12.9
4	268	85.1	4–5	0.41	11.6
5	240	76.2	5–6	0.37	10.6
6	221	70.2	6–7	0.33	9.5
7	194	61.6	7–8	0.28	7.9
8	150	47.6	8–9	0.15	4.3
9	48	15.2	9–10.1	0.03	0.8
Total				3.52	100.0



6b

6a

FIG. 6a and 6b. JONES LAKE. Hydrographic chart and distribution of bottom sediments.



7a

7b

FIG. 7a and 7b. SALTERS LAKE. Hydrographic chart and distribution of bottom sediments.

TABLE 10

Singletary Lake

Bladen County, N. C. 34°36'N, 78°28'W.

Area	**572 acres**	**Maximum length**	**2630 yd., 1.49 mi.**
Volume	**6,495,300 yd.^{3}**	**Length shoreline**	**6900 yd., 3.92 mi.**
Maximum depth	**11.8 ft.**	**Shoreline development**	**1.17**
Mean depth	**7.0 ft.**	**Volume development**	**1.78**
		Number of soundings	**443**

DEPTH	AREA		STRATUM	VOLUME	
	Acres	Per cent of total		Yd.^{3} × 10^6	Per cent of total
feet			*feet*		
0	572	100.0	0–2	1.80	27.6
2	541	94.6	2–3	0.85	13.1
3	513	89.8	3–4	0.79	12.1
4	465	81.3	4–5	0.70	10.9
5	409	71.6	5–6	0.62	9.5
6	358	62.6	6–7	0.55	8.5
7	326	57.0	7–8	0.49	7.5
8	277	48.5	8–9	0.37	5.8
9	190	33.2	9–10	0.23	3.5
10	96	16.8	10–11	0.09	1.4
11	24	4.2	11–11.8	0.01	0.2
Total..				6.50	100.1

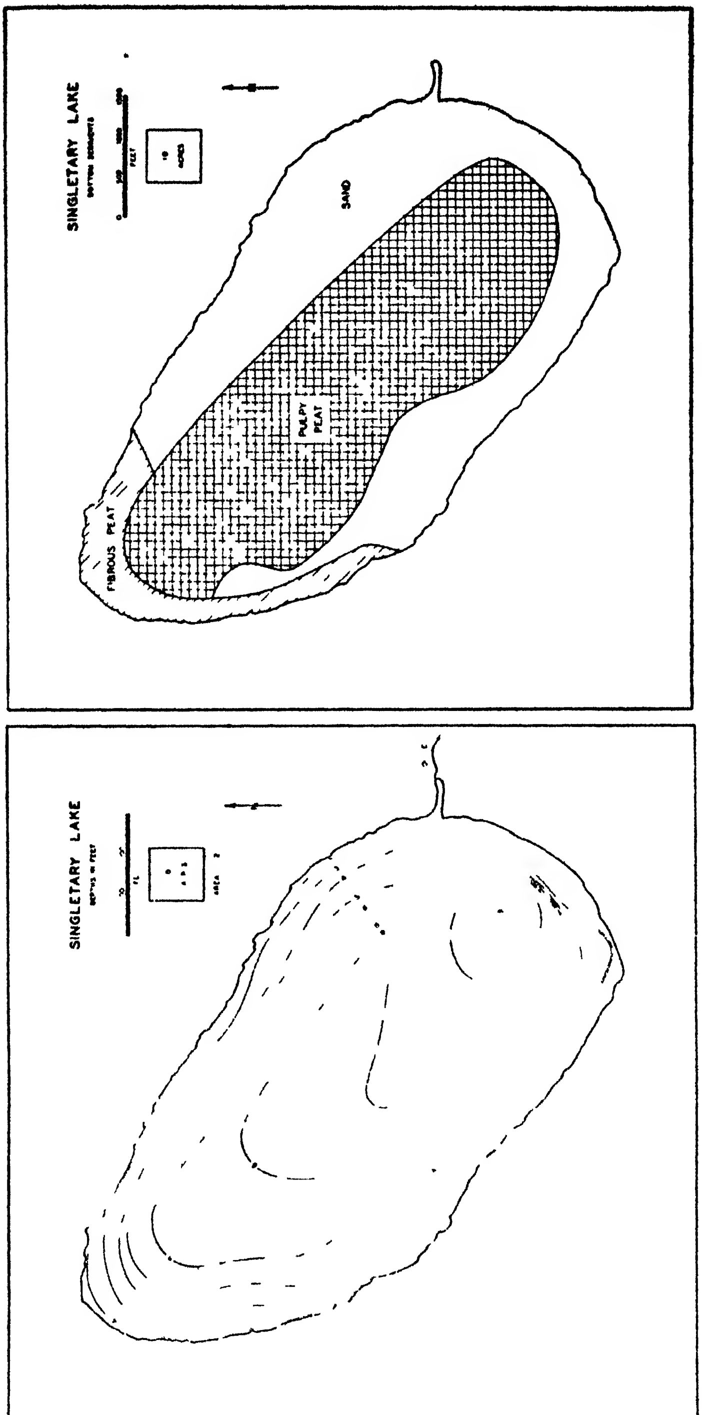
TABLE 11

White Lake

Bladen County, N. C. 34°39'N, 78°30'W.

Area	1068 acres	Maximum length	3190 yd., 1.81 mi.
Volume	12,844,100 yd.^{3}	Length shoreline	8400 yd., 4.77 mi.
Maximum depth	10.6 ft.	Shoreline development	1.04
Mean depth ..	7.5 ft.	Volume development	2.12
		Number of soundings	540

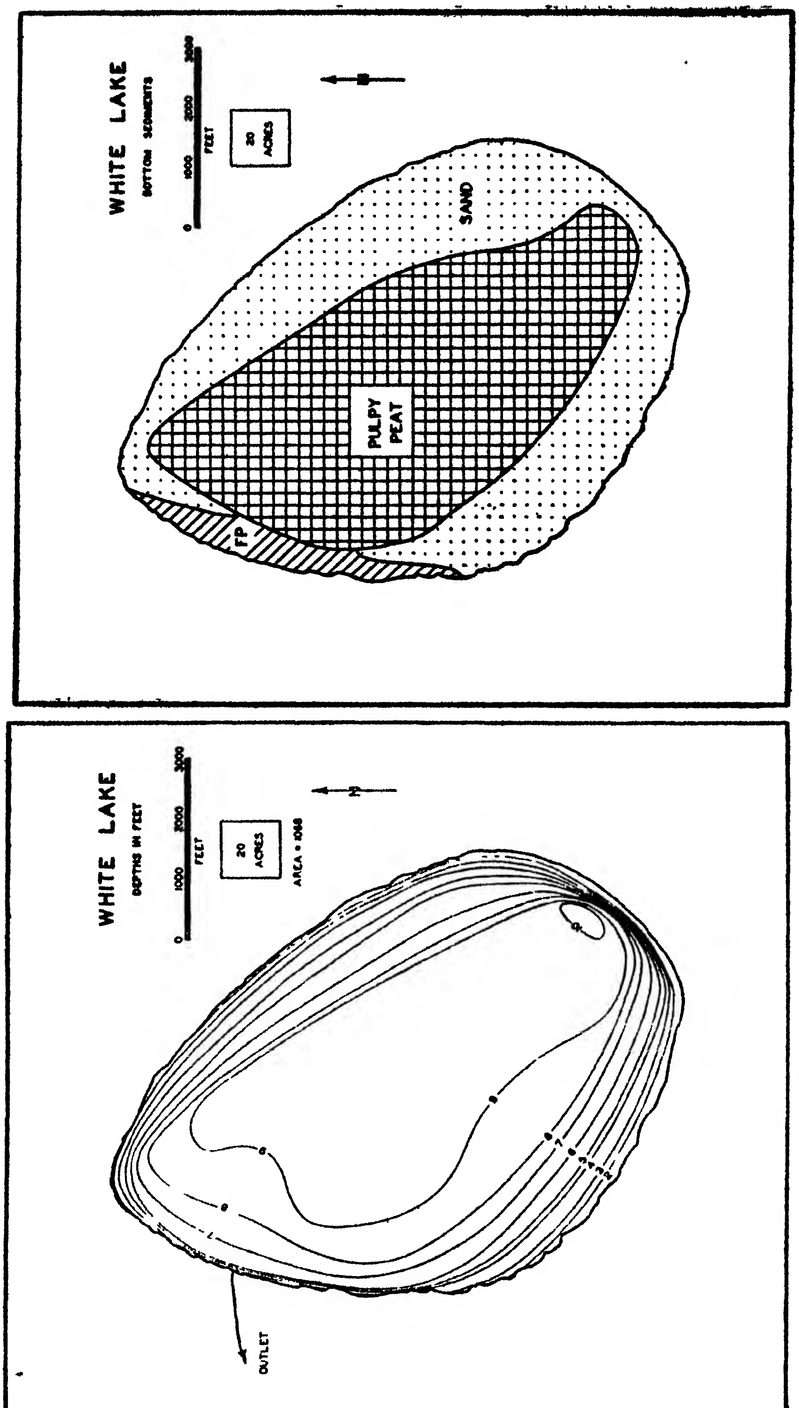
DEPTH	AREA		STRATUM	VOLUME	
	Acres	Per cent of total		Yd.^{3} × 10^6	Per cent of total
feet			*feet*		
0	1068	100.0	0–2	3.39	26.4
2	1033	96.7	2–3	1.64	12.8
3	1001	93.7	3–4	1.57	12.2
4	947	88.6	4–5	1.48	11.6
5	892	83.5	5–6	1.39	10.8
6	827	77.4	6–7	1.24	9.7
7	712	66.7	7–8	1.06	8.3
8	604	56.5	8–9	0.82	6.4
9	418	39.1	9–10	0.25	2.0
10	5	0.5	10–10.6	0.002	0.01
Total				**12.84**	**100.2**



8b

8a

FIG. 8a and 8b. SINGLETARY LAKE. Hydrographic chart and distribution of bottom sediments



9a 9b

FIG. 9a and 9b. WHITE LAKE. Hydrographic chart and distribution of bottom sediments.

TABLE 12

BLACK LAKE

Bladen County, N. C. 34°40′N, 78°25′W.

Area	1418 acres	Maximum length	3720 yd., 2.11 mi.
Volume	12,197,700 yd.³	Length shoreline	10,400 yd., 5.91 mi.
Maximum depth	7.1 ft.	Shoreline development	1.12
Mean depth	5.3 ft.	Volume development	2.24
		Number of soundings	356

DEPTH	AREA		STRATUM	VOLUME	
	Acres	Per cent of total		Yd.³ × 10⁶	Per cent of total
feet			*feet*		
0	1418	100.0	0–2	4.50	36.9
2	1369	96.5	2–3	2.17	17.8
3	1318	93.0	3–4	2.05	16.8
4	1224	86.3	4–5	1.76	14.5
5	970	68.4	5–6	1.31	10.7
6	664	46.8	6–7	0.41	3.3
7	10	0.7	7–7.1	+	0.004
Total				12.20	100.0

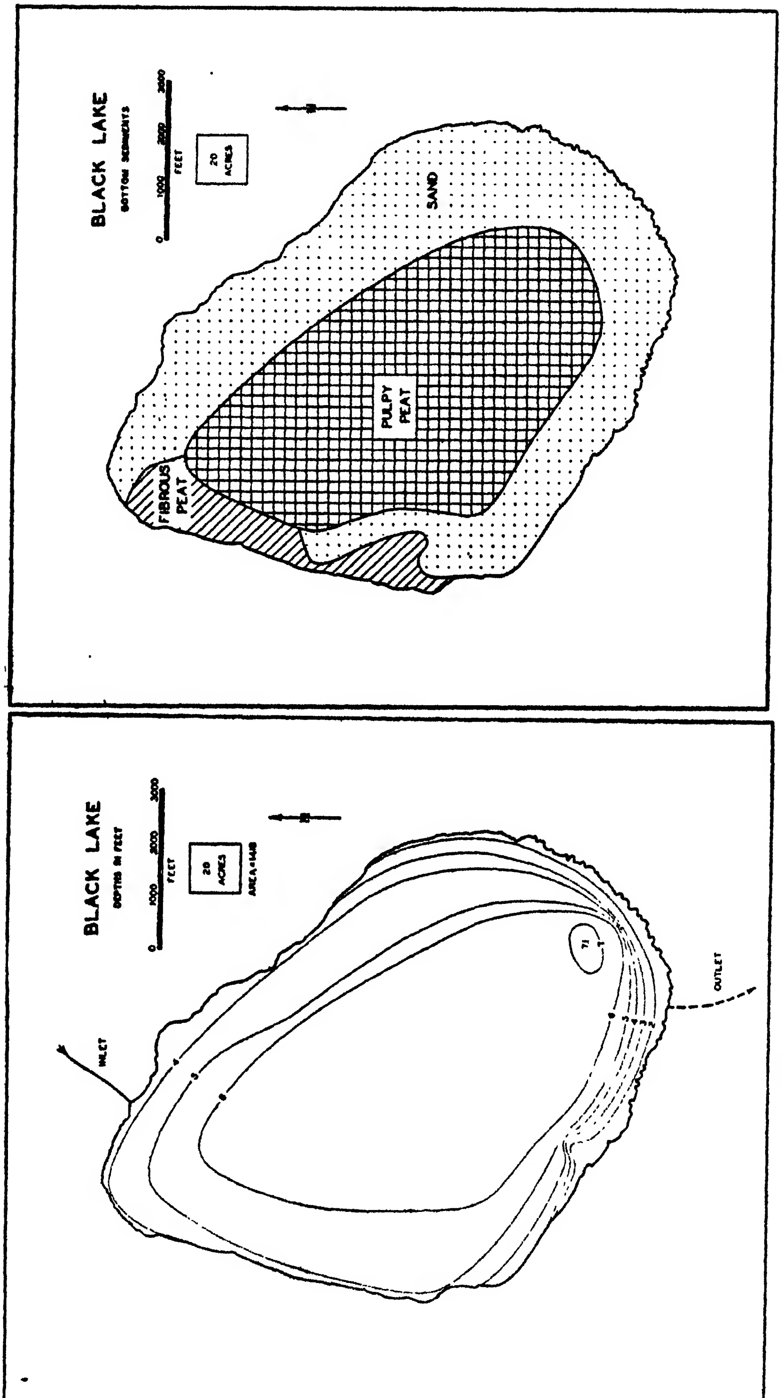
TABLE 13

LAKE WACCAMAW

Columbus County, N. C. 34°17′N, 78°30′W.

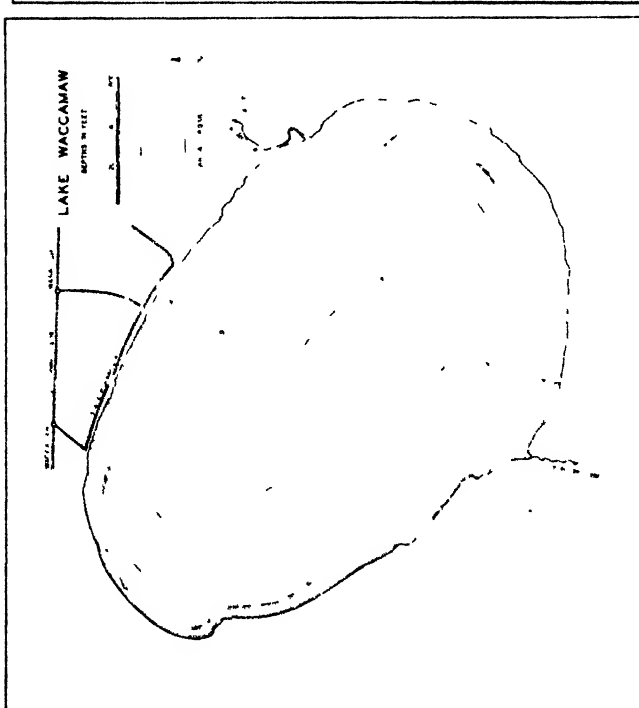
Area	8938 acres	Maximum length	9380 yd., 5.3 mi.
Volume	109,964,800 yd.³	Length shoreline	25,000 yd., 14.21 mi.
Maximum depth	10.8 ft.	Shoreline development	1.07
Mean depth	7.6 ft.	Volume development	2.11
		Number of soundings	502

DEPTH	AREA		STRATUM	VOLUME	
	Acres	Per cent of total		Yd.³ × 10⁶	Per cent of total
feet			*feet*		
0	8938	100.0	0–3	42.25	38.4
3	8523	95.4	3–4	13.17	12.0
4	7804	87.3	4–5	12.15	11.0
5	7264	81.3	5–6	11.25	10.2
6	6684	74.8	6–7	10.46	9.5
7	6289	70.4	7–8	9.79	8.9
8	5850	65.5	8–9	8.75	8.0
9	5002	56.0	9–10	1.41	1.3
10	1705	19.1	10–10.8	0.73	0.7
Total				109.96	100.0

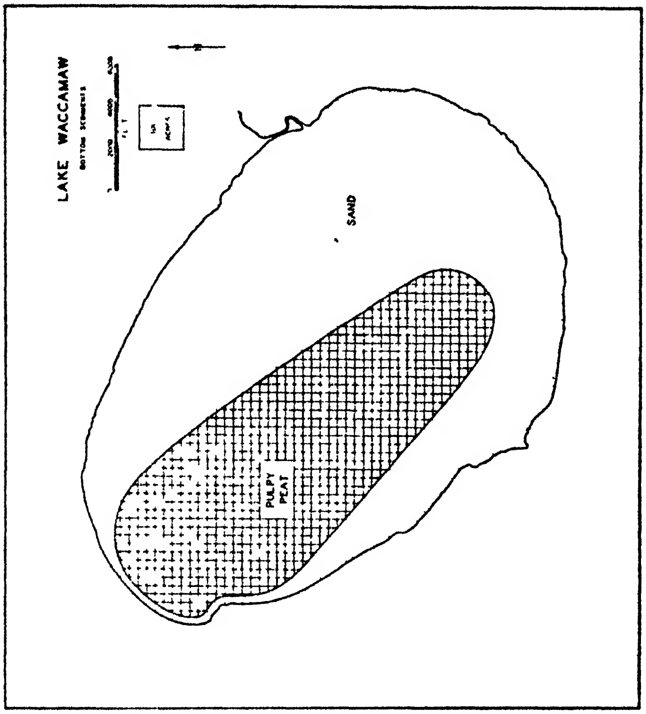


10a 10b

FIG. 10a and 10b. BLACK LAKE. Hydrographic chart and distribution of bottom sediments.



11a



11b

FIG. 11a and 11b. LAKE WACCAMAW. Hydrographic chart and distribution of bottom sediments.

TABLE 14

Chemical and physical observations on the Carolina bay lakes

LAKE	DATE	DEPTH	TEMP.	DISSOLVED O_2		pH	ML. N/44 NaOH PER L.	ML. N/44 H_2SO_4 PER L.	COLOR	DISC
		ft.	°C.	ppm.	per cent					ft.
Jones	13-VI-47	0	28.8	5.7	72		10.93		352	
		6	28.2	5.6	70		11.18	3.19	340	
	17-VI-47	0		6.1			11.13	3.28	340	2.3
		3		5.8			10.83	2.48	340	
		6		5.8			9.13	3.74	340	
	19-VI-47	0	27.9	6.4	81	4.36	11.13	3.15	340	2.1
		3	27.9	5.3	67		11.13	3.96	340	
		6	27.0	4.9	61		11.38	3.11	340	
	24-VI-47	0	24.8							2.3
	31-VIII-47	0				4.31	10.14	2.15	240	2.7
	10-VII-48								260	
Salters	23-VI-47	0	24.1	6.2	72	4.55	13.24	4.00	320	1 8
		3	24.1			4.46	8.83	3.32	352	
		6	24.1	5.9	70	4.44	9.18	3.13	340	
	24-VI-47									1.7
	27-VI-47	0	26.6							2.0
	1-VII-47	0	30.2							1.8
	3-VII-47	0	27.0			4.44	9.68	2.06	280	1.8
		3	27.0			4.51	9.33	2.81	280	
		6	26.8			4.51	9.08	2.69	280	
		8.5	26.7			4.53	9.03	3.13	280	
Singletary	10-VII-47									2.2
	11-VII-47	0	26.4	7.1	87	4.52	6.92	2.19	185	2.3
		3	26.0	7.1	87	4.50	6.92	2.06	180	
		6	25.0	7.0	84	4.51	6.87	2.11	180	
		7.5	24.9	6.9	82	4.53	7.67	2.18	180	
	19-VII-47	0	27.5			4.52	6.86	3.62	170	2.3
		3	27.4	6.4	79	4.55	6.92	2.74	170	
		6	27.3	6.3	77	4.54	6.37	2.56	170	
		9	27.2	6.2	77	4.54	6.82	2.56	170	
		10	27.1	5.9	73	4.51	6.82	2.65	185	
	1-IX-47	0				4.46	6.37	2.35	140	2.9
	4-X-47	0	18.9							2.6

TABLE 14—*Continued*

LAKE	DATE	DEPTH	TEMP.	DISSOLVED O_2		pH	ML. N/44 NaOH PER L.	ML. N/44 H_2SO_4 PER L.	COLOR	DISC
		ft.	°C.	*ppm.*	*per cent*					*ft.*
Singletary *Cont.*	5-X-47	0	19.4							2.9
	16-XI-47								170	
	10-VII-48								160	
White	26-VII-47	0	26.2	6.7	82	4.92	3.26	1.90	12	9
		3	26.2	7.1	86	4.90	3.76	1.85		
		6	26.2	7.1	86	4.95	3.51	1.60		
		7.5	26.2	7.3	88	4.97	3.26	1.69		
	2-VIII-47	0	29.5	6.3	81	4.90	3.71	1.69	<10	9
		3	29.1	6.4	82	4.94	3.36	1.39		
		6	29.0	6.4	82	4.87	3.46	1.43		
		8	29.0	6.5	83	4.91	3.41	1.39	<10	
	10-VII-48								<10	
Black	30-VIII-47	0	27.8	6.3	78	4.43	7.47	2.39	180	1.8
		3	27.5	6.5	80	4.41	7.17	1.98	170	
		6	27.2	6.6	82	4.46	7.47	1.99	175	
	4-IX-47	0	34.9	6.5	92	4.35	7.47	1.60	180	1.8
		1	34.4							
		2	31.0							
		3	29.5	6.6	85	4.38	7.78	1.47	190	
		6	26.6	5.9	72	4.39	7.98	1.68	190	
Waccamaw	15-VIII-47									4.5
	18-VIII-47	0	34.0	5.3	74	7.03	2.66	9.78	140	4.4
		2	30.2							
		3	29.5	5.0	64	6.95	2.66	9.33		
		6	28.6	4.8	61	6.95	3.01	9.28		
		9	28.3	4.6	58	6.92	3.31	9.04	140	
	23-VIII-47	0	30.1	6.1	80	6.91	3.87	8.74	160	4.8
		3	28.8	6.1	77	7.00	4.22	8.53		
		6	28.7	5.8	73	6.93	4.02	8.83		
		9	28.6	5.7	73	6.87	3.92	8.66	170	
	16-XI-47	0	13.2						175	3.8
Big Creek Inlet	23-VIII-47	0	24.0			5.42	24.40	6.89	360	
		0	24.4			5.22	25.45	4.45	400	

LEAF-CURL OF TOBACCO IN VENEZUELA

By Frederick A. Wolf[1]
Department of Botany, Duke University
Durham, North Carolina

Willard H. Whitcomb
Departamento de Entomología
Maracay, Venezuela

and

W. C. Mooney
Compañia Anónima Cigarrera Bigott, Sucs

INTRODUCTION

The native or criollo varieties of tobacco have long been cultivated in Venezuela although little attention has ever been given to their diseases. In recent years however, certain varieties of the Virginia, Burley, and Turkish types have been introduced there, and have been noted to be affected by several of the common and better-known diseases to which this crop is subject in other tobacco-growing regions of the world. Among the less well-known diseases recently found to occur throughout Venezuela is one known to plant pathologists as leaf-curl or kroepoek. This disease previously has been recorded from the Netherlands East Indies, Africa, and India, where investigations have shown that the causal agent is a virus which is transmitted by white-flies.

Apparently it has not been unequivocally established previously that tobacco leaf-curl occurs in the Americas although a disease tentatively identified as leaf-curl was reported on Burley tobacco in the State of São Paulo, Brazil (Costa and Forster, 1939). There seems little doubt now that the disease investigated in Brazil by Costa (1944) was leaf-curl. He found that the disorder in question was not a "physiological disease", was not transmissible by grafting, and was not caused by arachnids (presumably red spiders), and based his identification of it mainly on this negative evidence. These circumstances appear to warrant the presentation at this time of our findings on tobacco leaf-curl in Venezuela, together with a concise summary of the present status of knowledge of this disease.

HISTORICAL FEATURES

Presumably tobacco leaf-curl was first noted in the Netherlands East Indies, and its incidence there is the basis of an account by Peters and Schwartz (1912).

[1] Employed from October 15, 1947, to May 15, 1948, by the Ministerio de Agricultura y Cría, Departamento de Fitopatología, collaborating with Compañia Anónima Cigarrera Bigott, Sucs., and the Compañia Anónima Venezolana de Tabaco, Caracas, Venezuela. Special thanks are extended to the technicians of these companies for their cooperation, and also to Dr. Clifford H. Meredith, Jefe del Departamento de Fitopatología, for his continued interest and help in this study.

They regarded its cause as unknown. Ludwigs (1913) illustrated and briefly described this disease in the following year, on the basis of his studies in the Cameroons, West Africa. He concluded that tobacco leaf-curl is induced by water relations, noting that a large proportion of the crop was rendered worthless by the disease during the dry season, whereas in the same fields, during the rainy season, a few plants only were affected. He demonstrated that plants adequately supplied with water did not remain free from leaf-curl and he could not apply water in such a way as to induce affected plants to recover.

Thilliard (1921) found no clue to the identity of the infective agent during three years' studies of the disease in the Myombé Plains area of the Cameroons, and was unable to transmit leaf-curl by injecting sap from diseased plants into healthy ones.

Jensen (1920), in an extensive treatise on tobacco diseases in the province of Vorstenland, Java, regarded leaf-curl as of unknown etiology and as among the serious diseases in that region.

The cause of this leaf-curl disease was not established until essentially twenty years after the disorder was first definitely recognized, at which time Storey (1931) at Amani, Tanganyika, and Thung (1932) at Klaten, Java, almost simultaneously announced that it is induced by a virus which is transmitted by a species of white-fly.

A rather extensive series of studies on various phases of the leaf-curl problem has been conducted during the years that have elapsed since its cause was made known from the discoveries by Storey and Thung. These studies deal more specifically with (a) the geographical range of the disease, (b) the entities composing the leaf-curl virus-complex of tobacco and other plants, (c) the primary and alternative hosts and food plants used by the white-fly, and (d) the identity of the vector. Certain pertinent points from these findings may best be considered in the discussions that follow.

RANGE AND IMPORTANCE OF THE DISEASE

In Africa, tobacco leaf-curl has been reported from the Belgian Congo, Cameroons, Gold Coast, Madagascar, Morocco, Nigeria, Nyassaland, Rhodesia, Sierra Leone, Tanganyika, Transvaal, and Zanzibar. It also occurs in such other parts of the Eastern Hemisphere as Java, Sumatra, northern India, Romania, and Russia.

In the Western Hemisphere, as previously stated, it has been reported from Brazil only (Costa, 1944; Costa and Forster, 1939). In Venezuela, tobacco leaf-curl has been observed in the States of Anzóategui, Aragua, Carabobo, Distrito Federal, Guárico, Miranda, Monagras, Portuguesa, and Sucre. Its wide distribution and its wide incidence on criollo tobaccos in remote regions where for several centuries only these native varieties have been cultivated may be interpreted to indicate that the disease has long been present within Venezuela.

It seems agreed that leaf-curl must be regarded as a potentially important disease. The severity of the disorder is stated by Pruthi and Samuel (1942) to be directly correlated with the population of white-fly. These insects are more

abundant in the dry season than in the rainy season, and hence the disease is the more serious in the former period. Storey (1935) regards it as the most destructive tobacco disease in many parts of East Africa. Moore (1933, 1934) noted in East Africa, Rhodesia, and the Transvaal, that half of the crop may be affected in some fields and the entire crop in others. Epiphytotics in southern Rhodesia, in which all the plants were affected, are mentioned by Hopkins (1932). Thilliard (1921) stated that 60 per cent of the crop in the Cameroons was affected in 1917. Costa and Forster (1939) found leaf-curl present to the extent of one to five per cent in Brazil. Pal and Tandon (1937) state that the disorder is usually present in northern India to the extent of five to ten per cent, but that in some fields it virtually destroys the entire crop. In Venezuela, during the dry season, the disease generally involves from five to ten per cent of the crop, although one field of approximately ten hectares was abandoned and plowed up shortly after transplanting because essentially all the plants were affected.

THE DISEASE AND THE VIRUS COMPLEX

Leaf-curl is rarely seen on tobacco in seedbeds in Venezuela although on one hacienda the incidence of affected seedlings in the seedbeds was approximately ten per cent. Infection is usually first noted in the two- to three-week period immediately after transplanting. Young leaves of plants of any age are susceptible, however. Plants affected while young seldom recover and eventually become completely worthless. The uppermost leaves of nearly grown plants may be curled and twisted whereas the older leaves remain normal in appearance (Fig. 3). Occasionally plants are found having curled and twisted leaves in the median stem region although the lowermost and uppermost leaves on such plants may appear normal.

Leaf-curl, the common and generally accepted name of this disorder, fittingly describes one of its most characteristic features (Fig. 1 and 2). Usually too, diseased plants are greatly dwarfed (Fig. 4). Jensen (1920) states that the leaf of an affected plant presents the appearance of having been "kneaded and wrinkled in the hand and again partly unfolded from itself," hence he and plant pathologists in the East Indies have used such names for the disease as "kroepoek," "krupuk," "kroekoh," "kroesblaar," and "krulziekte." The Javanese call it "gilah." English-speaking investigators call it either "leaf-curl," "crinkle", "crinkly dwarf" or "cabbaging". Costa (1944) called it "encarquilhamento do fôlha." The German term "Faltenzwerg", meaning crinkling and dwarfing, is applied to this disease by certain investigators.

Apparently tobacco leaf-curl is not a single disease but a complex of diseases. Thung (1934) described three forms, which he designated common kroepoek, curl or crinkle disease, and transparent kroepoek. In common kroepoek, the leaves are much smaller than normal, their edges curve downward, the smaller veins are knotted and tortuous, and the larger lateral veins bear secondary leaf-like outgrowths or enations. Anatomical studies of such leaf-like structures by Kerling (1933) show that the morphological lower side is directed toward the lower side of the principal leaf. This kind of kroepoek appears to agree with "forma rugosa", as described by Costa.

FIG. 1. Leaf curl of Virginia tobacco from infection occurring soon after transplanting.

FIG. 2. Leaf curl involving the bud of a young plant. Such a plant will not produce harvestable leaves.

FIG. 3. Mature leaf-curl affected plant of Virginia tobacco. Lower leaves are deformed, thickened, and brittle. Plant is branched, with upper leaves severely curled and deformed. (Courtesy Ministerio de Agricultura y Cría, Departamento de Genetica.)

FIG. 4. At left, branched plant, without any normal leaves. At right, severely dwarfed plant. (Courtesy Ministerio de Agricultura y Cría, Departamento de Genetica.)

In the curl disease form, the stems are branched (Fig. 4), the margin of the entire leaf is rolled downward, but the midrib and veins are not knotty and crooked. Indefinite-margined yellowish areas usually occur on the oldest leaves that are thick and brittle. This form of leaf-curl is most common in Venezuela. In extreme cases the plants are much dwarfed and the axillary buds continue development to the extent that the plants are broom-like, and apical dominance of the main branch appears quite completely to have been lost. The flower parts, especially the calyx and corolla, are also curled and deformed.

In transparent kroepoek the leaf margins roll upward and the smaller veins tend to become transparent. This form of the disease resembles Costa's (1944) "forma enrolamento."

Pruthi (1937) and Pal and Tandon (1937) recognized five forms of tobacco leaf-curl, designating them A, B, C, D, and X. In forms A and B the plants are markedly stunted, are greener than normal and have leaf-like outgrowths on the larger veins; in A the leaves are smaller, are more curled and thickened, being rugose and brittle, whereas in B they are not thickened and not brittle. The accessory leaf-like outgrowths on the veins are lacking in forms C and D. In both forms the veins are translucent, but in C "stitches" of green occur along the veins. The X form of leaf-curl is a variable complex and appears to be a mixture of all other forms. Pruthi was able to transmit all five types from diseased to healthy plants by means of white-flies, and Pal and Tandon by grafting diseased onto healthy plants.

Kerling (1933), in trying to explain the complex nature of kroepoek, suggested that more than a single virus may be involved and that the white-fly transmits each of them. A further complication arises because some workers regard the cotton leaf-curl virus and the yuca or cassava, *Manihot esculenta* Cranz, leaf-curl virus as identical with the tobacco leaf-curl virus. Holmes (1939), however, regards these as three distinct viruses, a conclusion that is supported by the results to be recounted subsequently of our own reciprocal infection experiments.

THE VECTOR AND TRANSMISSION

The vector of the tobacco leaf-curl virus is known to entomologists generally as *Bemisia tabaci* Gennadius,[2] a member of the family Aleyrodidae. The name *B. gossypiperda*, however, has been widely used instead of *B. tabaci*. The binomial, *B. gossypiperda*, was created in 1929 by Misra and Lamda as a name for the vector of the cotton leaf-curl virus in India.

There now remains the certainty that other genera of aleyrodids and other species of Bemisia may serve as vectors of the tobacco leaf-curl virus, especially in the light of our findings and those by McClean (1940). He stated that *B. tabaci* has not been recorded in the Transvaal and that another aleyrodid, *Trialeurodes natalensis* Cobb, constitutes the leaf-curl virus vector there. In

[2] Gennadius, Agric. ellenica, 1889. Silvestri, in ENTOMOLOGIA APPLICATA GLI INSETTI 1: 401, 1934, considers *Bemisia gossypiperda* Misra and Lamba (1929) to be synonymous with *B. tabaci* Genn

Venezuela two species of Aleyrodidae,[3] *Bemisia tuberculata* Bondar and *Aleurotrachelus socialis* Bondar, have been found to be associated with tobacco leaf-curl. Neither species has been observed to breed in large numbers on tobacco, however, but instead mostly on yuca and on several other plant species growing near tobacco seedbeds and fields.

In our preliminary experiments on transmission of tobacco leaf-curl by these aleyrodids, use was made of field-collected insects, mostly from yuca. From ten to approximately one hundred such white-flies were liberated within each of the insect-proof cages, 60 x 60 x 60 cm. in size. Some of the cages covered a group of healthy tobacco seedlings together with one or two leaf-curl-affected plants. Under some of the control cages were placed both diseased and healthy tobacco plants, but without white-flies, and under other controls healthy tobacco plants and white-flies, diseased plants being omitted. Transmission experiments of this sort were made on three haciendas and in the insectary. As a result of enclosing together white-flies, diseased plants, and healthy seedlings under cages, in all locations, thirty-two per cent of the normal plants became leaf-curl-affected. Symptoms were first apparent on some seedlings after 12 days, and 33 days were required for development of the disease in others. All seedlings remained healthy in all cages with both types of controls.

As regards the period of incubation of this disease from other investigations, there is only general accord. Plants are first visibly diseased, as a rule, two to three weeks after viruliferous white-flies are liberated upon healthy plants. Thung (1934) states that the incubation period varies from 22 to 36 days. Undoubtedly a number of factors condition the length of the interval, among them being the age and vigor of the plants or leaves.

Other similar transmission trials involved a field of virus-infected yuca on which white-flies occurred in great abundance. Fifty healthy tobacco seedlings were transplanted on the windward side of this field. Half of these seedlings were immediately screened against white-flies and the others were left unprotected. None of these seedlings, either the protected ones or exposed ones, became affected with leaf-curl. From these results it may be concluded that the virus from yuca is unable to induce leaf-curl in tobacco. Further support for this conclusion stems from observations made in another yuca field which was also abundantly infested with white-flies. On February 24, it was noted that volunteer tobacco seedlings, growing between the rows of yuca, were free from leaf-curl. But on February 26, three leaf-curl-affected tobacco seedlings were transplanted into this field. As a consequence, when on March 9, this field was again visited, one volunteer tobacco seedling had become diseased with leaf-curl. On March 17 there were six additional diseased plants and on March 25, three more were affected. On the other hand, none of the volunteer seedlings became diseased when protected by use of insect-proof cages placed over them at the same time that diseased seedlings were transplanted near-by.

[3] We are grateful to Louise M. Russell, United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, Division of Insect Identification, to whom specimens were sent for identification of these white-flies.

Another test, using this same field, was begun March 18. Thirty tobacco seedlings were transplanted within a short distance of the leaf-curl-affected transplants. Half of them were left exposed to visitation by white-flies and the other half were kept protected under cages. By April 19 eleven of the fifteen seedlings left exposed had contracted leaf-curl whereas all screened plants had remained disease-free. It appears quite certain from these preliminary experiments that either species or both species of white-flies, *Bemisia tuberculata* and *Aleurotrachelus socialis*, are capable of transmitting the virus of tobacco leaf-curl.

There is no evidence to date that insects other than aleyrodids serve as leaf-curl virus vectors. Thung (1932) found that thrips and *Myzus persicae* Sulzer (an aphid) are unable, in Java, to transmit the leaf-curl virus. In Venezuela all the evidence in hand indicates that the suckfly or "mosquito", *Dicyphus minimus* Uhl., is unable to act as a virus vector.

Alternative hosts and food plants which have been reported to exhibit symptoms of leaf-curl after visitation by white-flies are listed below. Many investigators have contributed to this phase of the problem. It has been amply demonstrated that *B. tabaci*, the species that has been assumed generally to be the only vector, uses a wide variety of herbaceous and woody species of plants as food. Many of the plants subsequent to visitation by white-flies, exhibit symptoms of leaf-curl, whereas certain other species remain without symptoms. Moreover, in the light of these studies, it is exceedingly doubtful that a single virus constitutes the etiologic agent for all species that exhibit leaf-curl and that a single species of aleyrodid is the only vector. Many perplexing problems relating to food plants and vectors await solution by use of adequately controlled tests. Whether all the species of weeds and cultivated plants in the following list may properly be regarded as hosts of the tobacco leaf-curl virus has not been established with finality. The list, no doubt, includes hosts for three distinct viruses all transmitted by the same kinds of white-flies, but at this time no one can separate the list into three parts.

Compositae: *Acanthospermum hispidum* D C., *Ageratum conyzoides* L., *Calendula officinalis* L., *Carthamus tinctorius* L., *Cosmos bipinnatus* Cav., *Eupatorium odoratum* L., *Helichrysum monstruosum* Hort., *Inula vestita* Wall., *Launea asplenifolia* Hook., *Synedrella nodiflora* Gaertn., *Vernonia anthelmintica* Willd., *Vernonia cinerea* Less., *V. hirta* L., *Zinnia elegans* Jacq.

Convolvulaceae: *Ipomoea batatas* Poir.

Cruciferae: *Brassica napus* L., *B. oleracea* L., *B. oleracea* var. *botrytis* L., *B. rapa* L., *Raphanus sativus* L.

Cucurbitaceae: *Cucumis sativus* L., *Lagenaria vulgaris* Ser., *Luffa aegyptica* Mill., *L. acutangula* Roxb., *Trichosanthes anguina* Lam.

Euphorbiaceae: *Euphorbia hirta* L., *Manihot esculenta* Cranz.

Labiatae: *Anisomeles ovata* R. Br.

Leguminosae: *Arachis hypogaea L.*, *Cajanus cajan* Spring., *Cicer arietinum* L., *Crotolaria juncea* L., *Phaseolus calcaratus* Roxb., *Phaseolus mungo* L., *P. radiatus* L., *Glycine hispida* Max.

Linaceae: *Linum usitatissimum* L.

Malvaceae: *Althea rosea* Cav., *Gossypium herbaceum* L., *Hibiscus cannabinus* L., *H. esculentus* L., *H. rosa-sinensis* L., *Sida carpinifolia* L., *S. cordifolia* L., *S. humulis* Cav., *S. rhombifolia* L., *S. veronicaefolia* Lam.

Pedaliaceae: *Sesamum indicum* L.

Scrophulariaceae: *Scoparia dulcis* L.

Solanaceae: *Capsicum annuum* L., *Datura stramonium* L., *Lycopersicum esculentum* Mill., *L. pimpinellifolium* Mill., *Nicandra physaloides* Gaertn., *N. tabacum* L., *N. rustica* L., *N. glutinosa* L., *Petunia violacea Lindl.*, *Physalis angulata* L., *Physalis peruviana* L., *Solanum melongena* L.

Urticaceae: *Cannabis sativa* L.

Verbenaceae: *Stachytarpheta jamaicensis* Gardn.

Thung (1934) concluded that although many species of weeds in Java are used as food plants by *Bemisia tabaci* nevertheless only *Ageratum conyzoides*, *Synedrella nodiflora*, and *Vernonia cinerea* serve as sources of inoculum, and perpetuate the disease when there are no tabacco plants in the fields. Pruthi and Samuel (1942), by means of controlled experiments in which plants were maintained under insect-proof cages, showed that leaf-curl, in India, may be transmitted to tobacco from either *Ageratum conyzoides*, *Crotolaria juncea*, *Euphorbia hirta*, *Launea asplenifolia*, *Lycopersicum esculentum*, *Scoparia dulcis*, *Sida rhombifolia*, *Solanum nigrum*. *Vernonia cinerea*, or *Zinnia elegans*. Van der Lann (1940), by growing tobacco under insect-proof cages in Java, established that *Ageratum conyzoides*, *Eupatorium odoratum*, *Stachytarpheta jamaicensis*, and *Synedrella nodiflora* serve as reservoirs of tobacco leaf-curl virus.

McClean (1940), using diseased tobacco as a source of inoculum, induced leaf curl in *Datura stramonium*, *Helichrysum monstrosum*, *Lycopersicum esculentum*, *L. pimpinellifolium*, *Nicandra physaloides*, *Nicotiana glutinosa*, *Petunia violacea*, *Physalis peruviana*, and *Zinnia elegans*.

Although cotton is included in the foregoing host list, experiments by Storey (1935) showed that leaf-curl is not reciprocally transmissible between cotton and tobacco. Supportive evidence of non-identity of the cotton leaf-curl virus and the tobacco leaf-curl virus is presented by Pruthi and Samuel (1942). They report, for example, that cotton leaf-curl does not occur in some portions of northern India where the tobacco crop is affected, even though white-flies occur on cotton in sufficient numbers seriously to desap the plants.

Evidence remains meagre on the species of plants that serve as reservoirs of virus for the initiation of outbreaks on tobacco in Venezuela. The possibility of survival on tobacco should not be dismissed since at any time of the year there may be living tobacco plants in fields in any of the tobacco-growing regions. In some instances as indicated by our observations tomatoes may function in initiating the disease on tobacco since tomato leaf-curl is widely prevalent in Venezuela. Furthermore when diseased tobacco plants, healthy tomatoes, and white-flies were caged together, the tomatoes in due time became diseased, and when leaf-curled tomatoes, healthy tobacco plants, and white-flies were caged together, the tobacco became leaf-curled. Our results, therefore, support the

experiments involving reciprocal transmission of leaf-curl between tomato and tobacco, recently done in India by Vasudeva and Raj (1948).

SUMMARY

Leaf-curl of tobacco, long known in parts of the Eastern Hemisphere, is widely prevalent in Venezuela.

The diagnostic features of this disorder are curling, twisting and deformation of leaves together with a dwarfing of the plants. This disease is caused by a *virus* that is transmitted by white-flies. The vector in most of the Eastern Hemisphere has been identified as the aleyrodid *Bemisia tabaci*. In the Transvaal it has been identified as *Trialeurodes natalensis* and in Venezuela both *Bemisia tuberculata* and *Aleurotrachelus socialis*, also aleyrodids, may act as vectors.

Many species of plants, as listed herein from previous publications, after having been fed upon by viruliferous white-flies, develop leaf-curl.

It is highly probable that at least three distinct viruses are involved in this leaf-curl complex namely tobacco leaf curl virus, cotton leaf-curl virus, and yuca leaf-curl virus.

Various weeds serve as reservoirs of virus between successive crops of tobacco in the Eastern Hemisphere. Meagre evidence indicates that tobacco and tomato plants act in this capacity in Venezuela.

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THE REDESCRIPTION OF TWENTY-ONE SPECIES OF AREOPIDAE DESCRIBED IN 1923

By Z. P. Metcalf

Department of Zoology and Entomology, N. C. State College of Agriculture and Engineering of the University of North Carolina
Raleigh, North Carolina

Plates 1–4 and One Text Figure

In 1923 the author published a "Key to the Fulgoridae of Eastern North America" (Jour. Elisha Mitchell Sci. Soc. **38**: 139–230, pls. 38–70) in which he described twenty-one new species of the Family Areopidae. At that time not so much attention was being paid to the details of the male genitalia as is now required for the specific determination of species of this family, hence it has been deemed best to redescribe these species from the types.

In order to understand clearly the terminology used in describing the male genitalia of this family, a generalized drawing of the male genitalia of the group is attached. (Text fig. 1). The male genitalia of the Areopidae consists of the modified ninth, tenth, and eleventh abdominal segments. The ninth abdominal segment usually consists of a greatly swollen, somewhat spherical element called the pygofer. The ninth segment is open caudad. This opening is known as the genital opening. The genital opening is usually divided into two areas: the more dorsal, anal region, surrounding the anal segment (tenth segment) and the anal spine (eleventh segment); and the ventral area or genital region. The genital region is divided into an inner compartment and outer compartment by the diaphragm. The anal angle which is usually more or less prominent separates the anal region from the genital region. The aedeagus and its connectives are in the inner compartment and the genital styles are in the outer compartment. The connectives between the aedeagus and genital styles are composed of a basal connective and a pair of aedeagal struts which have a characteristic shape that is of importance in identifying the species. The ventral area of the genital opening is sometimes distinctly separated from the lateral margins by the ventral angles, and in some genera a pair of distinct plates are formed on the ventral border. These may be known as genital plates. In other genera the ventral area may be distinctly separated from the lateral margins of the pygofer which are usually distinctly swollen. This structure may be known as the ventral plate. The genital styles are sometimes simple, flattened, plate-like structures. They may, however, be very elaborate structures with a basal angle strongly developed or with the apical angles developed into elaborate and sometimes branched structures. The aedeagus is usually simple and tubular, sometimes with rows of spines in various areas, sometimes with distinct dorsal processes usually on basal half or with lateral processes usually on basal area. The dorsal margin of the diaphragm which bounds the inner chamber of

the ninth segment is sometimes modified with distinct plates or spines known as the plates of the genital armature. The tenth segment is usually provided with one, sometimes two, pair of anal spines. These spines are sometimes short, produced as anal lobes, sometimes very long, reaching in certain genera to the lower margin of the genital opening. The eleventh segment, known as the anal style, is usually simple, more or less conical and attenuate toward the apex.

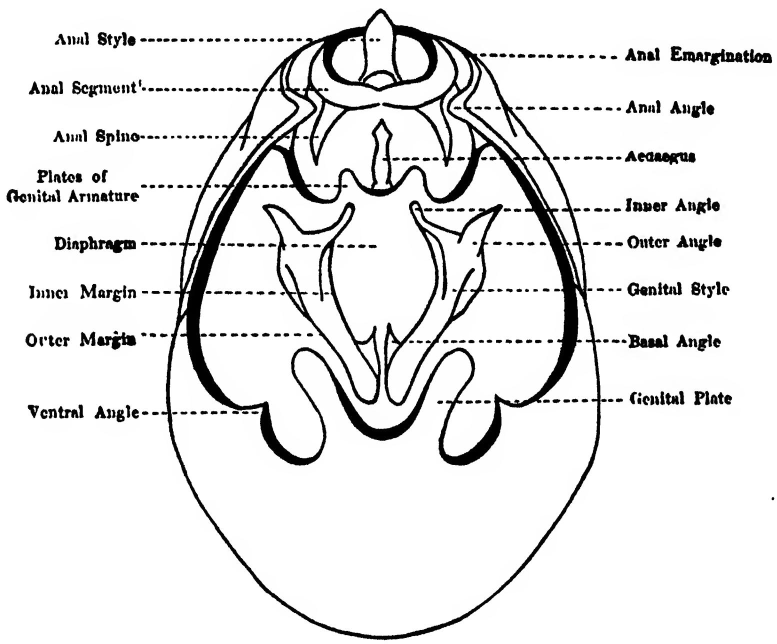


FIG. 1. Generalized view of the caudal aspect of the male genitalia of Areopidae.

Stenocranus arundineus Metc.

(Metcalf 1923a: 197)

(Pl. 1, fig. 5; Pl. 4, fig. 1)

This species may be recognized by its general light orange yellow color without conspicuous black markings except the black eyes and broad short vertex.

Pygofer elongate, narrow. Genital opening elongate, narrow, the outer compartment shallow. Anal angles not produced; ventral angles obtusely produced. Genital styles curving laterad and then gradually attenuate to acute apices which overlap at the tips, exceeding the dorsal margin of the diaphragm. Diaphragm narrow; dorsal margin broadly incised. Anal segment elongate, narrow, somewhat spatulate when viewed dorsad with two pairs of anal spines; the inner pair narrow, gradually acuminate to sharp apices which do not reach the dorsal margin of the diaphragm; outer pair flat, broadened somewhat to the apical third, then suddenly constricted, narrowing to acute apices which are overlapped by the dorsal margin of the diaphragm. Anal style narrow and elongate. Ae-

deagus slender with three apical processes; the dorsal process elongate, recurved at the apex. Aedeagal strut slender, elongate, expanded apically.

Holotype: ♂, Swannanoa, N. C., August 9, 1918. Herbert Osborn and Z. P. Metcalf.

Allotype: ♀, Swannanoa, N. C., August 9, 1918. Herbert Osborn and Z. P. Metcalf.

Paratypes: 10 ♂♂ and 10 ♀♀, collected at Swannanoa, North Carolina, August 1918, from Arundinaria sp.

Megamelanus terminalis Metc.

(Metcalf 1923a: 198)

(Pl. 1, fig. 4; Pl. 4, fig. 14)

This species may be recognized by the bicolored wings of the brachypterous male, the strongly spatulate vertex, and the straight lateral carinae of the pronotum.

Pygofer elongate when viewed caudad, longer than wide. Genital opening nearly twice as long as broad. Anal angles obtusely rounded. Diaphragm rather broad; median area distinctly produced, lobe-like. Genital armature with a pair of spine-like processes. Genital styles elongate; outer margin nearly straight; inner margin broadly incised; outer angle broadly rounded; inner angle strongly, acutely produced; genital styles meeting at their apices on the median line. Aedeagus tubular, broadly obtuse at the apex. Anal segment very short; two pairs of anal spines; dorsal pair very short, little more than the produced ventral angles; ventral pair elongate, slender, extending well below the dorsal margin of the diaphragm. Anal style relatively large. Aedeagal strut rather broad, broadly curved.

Holotype: ♂, Carolina Beach, Wilmington, N. C., June 4, 1920.

Allotype: ♀, Carolina Beach, Wilmington, N. C., June 4, 1920.

Paratypes: 5♂♂, Carolina Beach, Wilmington, N. C., June 4, 1920; 4♂♂, Cape Charles, Virginia, July 31, 1920, D. M. DeLong; 10♀♀, Carolina Beach, North Carolina, June 1920; 2♀♀, Cape Charles, Virginia, August 1, 1920, D. M. DeLong.

Megamelanus dorsalis Metc.

(Metcalf 1923a: 199)

(Pl. 2, fig. 7; Pl. 4, fig. 8)

This species may be recognized by its yellowish testaceous head and thorax, and blackish wings, and distinct genitalia.

Pygofer when viewed ventrad elongate, narrow; when viewed laterad elongate, nearly oval. Genital opening when viewed caudad broader than long. Genital chamber deep and the anal sinus deep. Anal angles not much produced. Genital styles elongate, club-shaped; outer margin sinuate; inner margin broadly incised toward the apex; inner and outer angles produced. Diaphragm broad, produced into a pair of curved hook-like processes on the median line, broadly

carinate ventrad of these processes. Anal segment short, rather broad, almost concealed by the pygofer with a pair of short, hook-like anal spines. Anal style short and broad, nearly triangular in outline. Aedeagus elongate, obtuse at the apex. Aedeagal strut rather broad and nearly straight.

Holotype: ♂, Atlantic City, New Jersey, August 25. W. J. Gerhardt.

Allotype: ♀, Atlantic City, New Jersey, August 25. W. J. Gerhardt.

Paratype: ♂, Pascagoula, Miss., August 6, 1921. H. L. Dozier.

Megamelanus lautus Metc.

(Metcalf 1923a: 200)

(Pl. 1, fig. 1; Pl. 4, fig. 6)

This species bears a superficial resemblance to *Megamelanus dorsalis* but the vertex is longer, narrower, the wings are more elongate, brownish fuscous, spotted with white, and the genitalia are distinct.

In this species the pygofer is short and broad; when viewed laterad nearly one and one-half times as long as broad; the dorso-lateral angle broadly rounded, not conspicuous; when viewed caudad the length about the same as the width. Outer chamber shallow. Genital styles nearly rectangular, thick, about five times as long as broad. Bases closely approximate, diverging from each other at about 35 degrees; outer apical angle broadly rounded; inner apical angle acutely produced, reaching beyond the dorsal margin of the diaphragm. Diaphragm large; dorsal margin broadly U-shaped; median line slightly elevated; genital armature with a pair of short, plate-like processes slightly deflexed on the ventral apical angle. Anal segment large; caudal angle produced into a narrow lobe-like process. Anal spines elongate, very slender, gently curved; apex rather acute. Anal style short, broad, ovate. Aedeagus short, obtuse at the apex, complex at the base. Aedeagal strut elongate, narrow at base, widened at apex.

Holotype: ♂, Loma, Texas, December 11, 1910. In the collection of the Illinois State Laboratory of Natural History.

Allotype: ♀, Loma, Texas, December 11, 1910.

Paratypes: ♂, Sarita, Texas, December 5, 1911; ♂, Ocean Springs, Miss., August 15, 1921. H. L. Dozier.

Megamelus distinctus Metc.

(Metcalf 1923a: 201)

(Pl. 2, fig. 10; Pl. 3, fig. 6)

This species may be recognized by its pale frons with the black clypeus and distinct genitalia.

Pygofer elongate. Genital plates distinct, consisting of a pair of lateral lobes which are strongly inflated, broadly rounded at the apex and a median pair of flattened plate-like structures which are triangular at the base; apex produced into a tongue-like process. Outer chamber shallow. Genital styles small, almost concealed by the genital plates, somewhat enlarged basad, gradually

narrowed toward the apex with the inner angle produced triangular. Aedeagus very long, reaching almost to the anterior margin of the pygofer when viewed caudad, broadly curved when viewed laterad with a distinct dorsal process which is obtuse apically, arising from the apex of the basal third. Aedeagal strut short, flat, slightly undulate on both margins. Anal segment short. Anal style elongate.

Holotype: ♂, Portland, Conn., July 25, 1920. B. H. Walden.

Megamelus aestus Metc.

(Metcalf 1923a: 202)

(Pl. 2, fig. 5; Pl. 4, fig. 2)

This species may be recognized by its general blackish color with a median pale vitta evident dorsad and distinct genitalia. Face, antennae, legs, and venter except the abdomen, pale yellow.

Pygofer divided into two areas. A broad ventral plate evident with the lateral areas strongly inflated with a pair of median genital plates elongate, nearly parallel-sided to the apex which is somewhat obtuse. Dorsal area not so strongly inflated. Genital styles small, enlarged at the base, constricted at the middle with the apex expanded; inner angle elongate, rather acute; outer angle broadly rounded. Diaphragm projecting dorsad with an elongate U-shaped incision on the median line and bearing two pairs of acute, spine-like processes; the dorsal pair short; ventral pair elongate, apex curved outward. Outer chamber deep. Aedeagus elongate, slender with an elongate lateral process originating near the base and more than half as long as the aedeagus; with numerous spines on the middle third, apical third smooth and spineless. Aedeagal strut nearly straight, parallel-sided. Anal segment greatly flattened, lateral lobes broadly rounded; in dorsal aspect somewhat spatulate, lateral margins expanding somewhat from the base to the broad apical lobes. Anal style elongate, sagittate with a distinct dorsal lobe at the base.

Holotype: ♂, Carolina Beach, N. C., June 7, 1920. Z. P. Metcalf.

Megamelus inflatus Metc.

(Metcalf 1923a: 203)

(Pl. 2, fig. 3; Pl. 4, fig. 13)

This species may be recognized by its almost uniform pale yellow color with the pygofer of the male strongly inflated, ventral plate complex.

Pygofer rather large, broadly inflated. Ventral plate very distinct; quadrate basal area distinctly set off from the pygofer; dorsal margin with a distinct V-shaped median notch and a small but distinct median spine; genital plates strongly produced with a V-shaped median notch at the apex. Genital styles approximate to apical third, then strongly divergent to rounded apical lobes with the inner angle somewhat produced. Diaphragm long with a V-shaped notch on dorsal margin; dorsal margin produced on the median line. Aedeagus long and slender, nearly straight with a distinct tooth on the dorsal margin about

the middle. Aedeagal strut long and slender, distinctly elbowed at the apex. Anal segment elongate without anal spines. Anal angle inconspicuous. Ventral angle concealed by the genital plates.

Holotype: ♂, Mill Neck, New York, June 19. N. Banks. In the collection of the Museum of Comparative Zoology.

Paratype: ♂, Mill Neck, New York, June 19. N. Banks.

This distinct little species has evidently been confused in the past with *Megamelus notulus* but the male genitalia are entirely distinct.

Megamelus uncus Metc.

(Metcalf 1923a: 204)

(Pl. 2, fig. 11; Pl. 3, fig. 2)

This species may be recognized by its general pale yellow color with the lateral borders of the abdomen broadly black and distinct male genitalia.

In this species the pygofer is broad, strongly inflated. Genital plates arising from a somewhat quadrate ventral plate at the base, narrow, elongate, and incurved. Outer genital chamber large with the diaphragm high, distinctly produced on median area with an apical V-shaped notch, thus producing a pair of plates which are distinctly curved caudad. Genital styles broad, flat, with the outer angle strongly produced. Aedeagus elongate, slender, decurved at the apex with slender recurved spine near apex of basal half. Aedeagal strut, elongate, narrow, somewhat undulate. Anal segment long with a distinct pair of anal spines which are long and acute. Anal style short, rather broad.

The holotype and allotype of this species were labeled simply Anticosti. The only Anticosti listed in Lippincott's Gazetteer is Anticosti Island in the St. Lawrence Bay. I have since learned, however, that these specimens were collected along Anticosti Creek in the District of Columbia.

Holotype: ♂, Anticosti, D.C., August 29. In the collection of the Museum of Comparative Zoology.

Allotype: ♀, Anticosti, D. C., August 29. In the collection of the Museum of Comparative Zoology.

Megamelus anticostus Metc.

(Metcalf 1923a: 204)

(Pl. 2, fig. 13; Pl. 3, fig. 4)

This species may be recognized by the evident pale dorsal vitta, and it is very close to *Megamelus uncus*, but differs in the details of the genitalia.

Pygofer short and very broad. Ventral area strongly inflated and deeply incised on either side of the genital plates. Genital plates elongate; inner margin incised just before the apex with the inner angle obtusely produced; outer margin nearly straight. Genital chamber deep. Diaphragm high, produced into a broad, nearly quadrate plate on the median line with the plate deeply triangularly incised mediad. Genital styles nearly horizontal, enlarged at the base, reduced to acute points at the apex. Aedeagus long and slender, needle-like,

somewhat curved at the base with an elongate recurved process at the apex of the basal third. Aedeagal strut long and narrow, distinctly sinuate. Anal segment elongate with a pair of distinct anal spines which are curved outward. Anal style short and broad.

The holotype and allotype of this species were labeled simply Anticosti. The only Anticosti listed in Lippincott's Gazetteer is Anticosti Island in the St. Lawrence Bay. I have since learned, however, that these specimens were collected along Anticosti Creek in the District of Columbia.

Holotype: ♂, Anticosti, D. C., August 29.

Allotype: ♀, Anticosti, D. C., August 29.

Pissonotus speciosus Metc.

(Metcalf 1923a: 205)

(Pl. 1, fig. 6; Pl. 3, fig. 3)

This species may be recognized by its small size, bright colors, and distinct genitalia.

Pygofer short, narrow and high. Ventral angles slightly produced. Genital opening large; anal angles inconspicuous. Outer chamber rather deep. Genital styles flat, plate-like, approximate on their bases, diverging at an angle of about 90 degrees, then twisting with the inner apical angle produced, the outer apical angle broadly rounded. Diaphragm fairly high, distinctly produced in an acute triangular plate; anal segment rather large with two broadly flattened anal spines which are broad at the base, suddenly constricted at about the middle and then slightly expanded to the obtuse apex. Anal style short, terete at the base, somewhat flattened and rather acute at the apex. Aedeagus tubular, not very long. Aedeagal strut elongate, slightly obtusely expanded on the dorsal margin near the base.

Holotype: ♂, Wrentham, Mass., June 27, 1920. G. W. Barber.

Paratypes: 2♂♂, Wrentham, Mass., June 27, 1920. G. W. Barber.

Pissonotus fulvus Metc.

(Metcalf 1923a: 206)

(Pl. 2, fig. 1; Pl. 4, fig. 12)

This species may be recognized by its almost uniform ochraceous orange color with only the eyes and tips of the tarsi black.

Pygofer large. Genital region of the genital aperture small, almost completely covered by the median genital plate; anal portion very large; anal emargination broadly carinate. Genital plate very large, consisting of two obtuse lateral lobes and a single median lobe which is broadly oval in outline with the dorsal margin with a broad V-shaped notch. Diaphragm large, broadly curved on the dorsal margin. Anal segment large; anal spines broad and flat, broadly oval at the base, suddenly constricted at the middle and narrowed to the acute apex. Genital styles small. Anal style short and broad, almost circular in outline. Aede-

agus elongate, tubular with two pairs of processes at the apex. Aedeagal strut nearly straight, slender, somewhat enlarged at the base and slightly curved.

Holotype: ♂, Paxton, Illinois, July 30, 1916.

Allotype: ♀, Paxton, Illinois, July 30, 1916.

Paratype: ♂, Metropolis, Illinois, August 19, 1916.

Pissonotus nigridorsum Metc.

(Metcalf 1923a: 206)

(Pl. 1, fig. 7; Pl. 4, fig. 4)

This species may be recognized by its general shining black color with the clypeus and legs bright yellow.

Pygofer elongate, narrow. Genital opening narrow, elongate; anal emargination deep. Outer genital chamber deep. Genital plates slender, blade-like, acute at the edge. Genital styles broad, thin, approximate at the base, divergent at an angle of about 90 degrees; the apices strongly reflexed, cup-like. Diaphragm simple with a deep V-shaped notch on the dorsal margin. Aedeagus when viewed caudad, elongate, slender, decurved, sagittate at the apex; when viewed laterad, rather broad and flat. Anal segment rather short, almost included in the anal emargination, with a pair of horn-like anal spines, which are somewhat bulbous at the base, then terete and acuminate, recurved. Anal style elongate, slender.

Holotype: ♂, Greenburg, Pa., September 18, 1904. M. Wirtner.

Delphacodes shermani Metc.

(*Liburnia shermani* Metcalf 1923a: 207)

(Pl. 1, fig. 8; Pl. 3, fig. 1)

This species is close to *L. campestris* Van Duzee but may be recognized by the entirely distinct genitalia.

Pygofer when viewed ventrad slightly broader than long, nearly quadrate, with a distinct median impression caudad; when viewed caudad almost as broad as high, the genital opening very large; anal angles scarcely produced; ventral angles inconspicuous; anal emargination not very deep. Diaphragm very high with the dorsal margin incised, V-shaped, with the lateral margins slightly sinuate; median area somewhat produced. Outer chamber not very deep. Genital styles broad and somewhat bulbous at the base, stem narrow, apex broad and capitate with both the inner and outer angles strongly produced; outer angle obtuse, inner angle acute. Aedeagus broad and short, obtuse at the apex. Aedeagal strut slender, not very long. Anal segment when viewed dorsad nearly quadrate in outline; when viewed caudad short, terete with the median area somewhat produced and a pair of short triangular anal spines. Anal style short and broad.

Holotype: ♂, Raleigh, N. C., late July. F. Sherman.

Allotype: ♀, Raleigh, N. C., late July. F. Sherman.

Paratypes: 5 ♀ ♀, Raleigh, N. C., late July. F. Sherman.

Delphacodes campestris Van D.

(Muir and Giffard 1924a: 25)

(*Liburnia unda* Metcalf 1923a: 207)

(Pl. 2, fig. 6; Pl. 4, fig. 7)

This is a pale species quite similar to *Liburnia detecta* Van Duzee but may be recognized by its distinct genitalia.

Pygofer short. Genital opening slightly longer than broad; ventral angle slightly produced; anal angles strongly produced; the lateral margin of the genital opening curving outward between the two angles. Outer chamber shallow. Diaphragm rather broad. Genital armature consisting of two reflexed processes which are lined with minute spines on the outer margin; the two are closely appressed on the median line and give the impression, at low power, of consisting of a single tongue-like process. Genital styles elongate, reaching the dorsal margin of the diaphragm, closely approximate on the inner margin; basal angles slightly but not conspicuously produced; outer margin broadly curved; outer angle obtuse; inner margin curved outward at the base and then curved inward toward the apex; the apical angle rather conspicuous. Ventral sinus shallow. Aedeagus compressed, broad at the base, narrow at the apex and produced into a conspicuous dorsal process, usually with a row of minute spines along the dorsal margin at the base. Aedeagal strut compressed, nearly linear in outline with the dorsal apical margin somewhat produced. Anal segment short, nearly concealed by the strongly produced margins of the anal emargination. Anal style elongate, narrow, slightly sagittate.

When I described *Liburnia unda* originally, I had an entirely different species in mind as the *Liburnia campestris* Van D. Muir and Giffard's re-examinations, descriptions, and drawings of the type of *campestris* enable me to make this correction in the synonomy.

Holotype: ♂, Carolina Beach, near Wilmington, N. C., June 6, 1920. Z. P. Metcalf.

Allotype: ♀, Carolina Beach, near Wilmington, N. C., June 6, 1920. Z. P. Metcalf.

Paratype: ♂, Carolina Beach, near Wilmington, N. C., June 6, 1920. Z. P. Metcalf.

Euidella triloba Metc.

(*Liburnia triloba* Metcalf 1923a: 208)

(Pl. 2, fig. 2; Pl. 3, fig. 5)

This species may be recognized by its dull ochraceous brown color, large size, and distinct genitalia.

Pygofer small. Genital region of the genital opening very large; anal region broad and short; anal angle conspicuously produced, elongate, triangular, obtuse at the apex; outer chamber deep. Genital styles complex; bases approximate, shaft curved caudad, then dorsad and terminating in a tri-lobed apical

region with the inner angles overlapping at the apex. Diaphragm not very broad with a broad U-shaped dorsal margin; genital armature complex, consisting of two pairs of spines; a large median pair which curve dorsad, caudad and then ventrad; and a slender lateral pair which curve toward the median line and dorsad to reach the lower margin of the anal segment. Anal segment small without anal spines. Anal style elongate, ovoid. Aedeagus curved, rather broad at the base, narrowed apically and suddenly expanded into two obtuse lobes. Aedeagal strut elongate with a distinct finger-like process at the apex.

Holotype: ♂, New Orleans, La.

Paratypes: 2 ♂♂, Titusville, Fla., November 8, 1911. Cornell University collection.

Delphacodes alexanderi Metc.

(*Liburnia alexanderi* Metcalf 1923a: 209)

(Pl. 2, fig. 4; Pl. 4, fig. 5)

This species may be recognized by the pale yellow color of the head, thorax and legs; the frons, wings and abdomen largely black.

Pygofer rather long. Genital opening large; anal and ventral angles barely indicated. Diaphragm not very high. Outer chamber rather deep. Genital styles conspicuous, approximate on the basal third, then diverging at an angle of about 70 degrees; together somewhat lyre-shaped; outer margin strongly sinuate; outer apical angle acute; inner margin incised on the basal half, the apical half broadly curved to the acute apex. Aedeagus short and blunt, apical area with two rows of small spines, the apical third with a row of stout dorsal spines. Aedeagal strut rather stout, T-shaped. Anal segment small; anal spines close together, somewhat horn-like and rather acute at the incurved apex. Anal style sagittate.

Holotype: ♂, Swannanoa, N. C., August 25, 1919. H. Osborn and Z. P. Metcalf.

Paratypes: ♂, Urbana, Illinois; ♂, Dongola, Illinois, August 21, 1916; ♂, Tupelo, Miss., March 22, 1921, H. L. Dozier; ♂, Falls Church, Va., August 24, N. Banks.

Delphacodes fulvidorsum Metc.

(*Liburnia fulvidorsum* Metcalf 1923a: 210)

(Pl. 2, fig. 9; Pl. 3, fig. 7)

This species may be recognized by the pale yellow color of the frons, vertex, thorax and legs; wings and the abdomen largely black.

Pygofer short and broad. Anal angle produced. Outer chamber shallow. Genital styles rather broad, short; outer margin nearly straight; inner margin broadly incised; apical margin nearly truncate; inner angle slightly produced; outer angle broadly produced, when viewed laterad distinctly sock-shaped. Diaphragm short, incised on the dorsal margin with an obtuse median carina below the incision; genital armature consisting of a pair of closely approximate

short spine-like processes. Aedeagus elongate, tubular with a distinct spine-like process at the base. Aedeagal strut short, L-shaped, basal portion slipper-shaped with an elongate heel. Anal segment short, broad, with a pair of slender anal spines which are curved outward. Anal style elongate, slender.

Holotype: ♂, Brownsville, Texas, December 10, 1910.

Paratypes: 2 ♂♂, Brownsville, Texas, December 10, 1910.

Euidella gerhardi Metc.

(*Liburnia gerhardi* Metcalf 1923a: 210)

(Pl. 1, fig. 2; Pl. 4, fig. 11)

This species may be recognized by its general bright ochraceous yellow color, with the frons narrow, and distinct genitalia.

Pygofer very short and broad. When viewed caudad about as broad as high. Genital opening large; anal angles strongly produced. Outer chamber rather deep; ventral angles not much produced, very obtuse. Genital styles biramose; bases bulbous; inner angle strongly produced, broadly obtuse; outer angle elongate, acute; a distinct, somewhat horn-like process arising from the inner surface just beneath the inner angle. Diaphragm large, broadly V-shaped. Aedeagus short, obtuse at the apex. Anal segment short. Anal spines elongate, reaching the dorsal border of the diaphragm, horn-shaped, curving toward the median line and rather obtuse at the apex. Anal styles short, almost as broad as long, somewhat tongue-like.

Holotype: ♂, Beverly Hills, Ill., August 31, 1907. W. J. Gerhard.

Allotype: ♀, Beverly Hills, Ill., August 31, 1907. W. J. Gerhard.

Paratype: ♀, Chicago, Ill., July 5, 1907.

Delphacodes staminata Metc.

(*Liburnia staminata* Metcalf 1923a: 211)

(Pl. 1, fig. 3; Pl. 4, fig. 10)

This species may be recognized by its pale color, with the frons strongly constricted between eyes, the genital styles slender, the apices suddenly expanded.

Pygofer elongate; when viewed laterad, broadly triangular in outline; when viewed caudad, longer than broad. Genital opening large; anal region especially large; anal angles not produced; ventral angles broadly obtuse, not conspicuous. Diaphragm not very high, produced into a broad median lobe; median line strongly carinate. Genital styles slender, elongate, produced beyond the dorsal margin of the diaphragm; bases approximate; outer margin broadly sinuate; inner margin nearly straight; outer apical angle produced; inner apical angle produced; apical margin broadly produced. Anal segment short; anal spines broad, flat, reaching ventrad beyond the dorsal margin of the diaphragm. Anal style short. Aedeagus simple.

Holotype: ♂, Chicago, Ill., July 25. W. J. Gerhard.

Delphacodes waldeni Metc.

(*Liburnia waldeni* Metcalf 1923a: 212)

(Pl. 2, fig. 12; Pl. 4, fig. 3)

This species may be recognized by its uniform dull brown color and short male pygofer.

Pygofer short and very broad. Genital opening narrow, distinctly widened dorsad; anal angles somewhat produced. Genital styles elongate, rather narrow; bases approximate; basal angle obtusely produced; outer margin broadly incised; inner margin also incised; inner and outer apical angles short, triangular; apical margins produced into an elongate triangular process reaching the anal segment. Outer genital chamber rather deep. Diaphragm not very broad, deeply incised on the thick, dorsal margin. Anal segment broad; anal spines short; anal style short, broad, somewhat sagittate. Aedeagal strut somewhat T-shaped. Aedeagus short, broad, tongue-shaped, obtuse at the apex.

Holotype: ♂, New Haven, Conn., August 8, 1920. B. H. Walden.

Criomorphus conspicuus Metc.

(Metcalf 1923a: 212)

(Pl. 2, fig. 8; Pl. 4, fig. 9)

This species has a general resemblance to *Phyllodinus flabellatus* Ball but the tibiae are terete, not expanded and the median frontal carina is forked on the clypeal margin.

Pygofer short and broad. Genital opening broader than long, almost triangular in outline with a shallow ventral sinus. Outer chamber shallow. Genital styles elongate, nearly horizontal at the base; bases approximate; apex acute, elongate, curved dorsad; outer and inner margins distinctly sinuate. Diaphragm long; dorsal margin produced on median line into a short triangular tube which projects caudad in a triangular process, distinctly carinate on the median line. Anal segment short; anal spines elongate, rather broad at the base, overlapping the dorsal margin of the diaphragm. Anal style short, triangular. Aedeagus short, somewhat expanded at the base and slightly bulbous at the apex which is set with numerous short triangular spines. Aedeagal strut short, somewhat T-shaped, distinctly projecting on the caudal border.

Holotype: ♀, New Haven, Conn., June 1920. B. H. Walden.

Paratypes: ♀, Urbana, Ill., June 1913; ♀, Forest Hills, Mass., August 1919.

DESCRIPTIONS OF PLATES

Plate 1

Fig. 1. Megamelanus lautus
Fig. 2. Euidella gerhardi
Fig. 3. Delphacodes staminata
Fig. 4. Megamelanus terminalis
Fig. 5. Stenocranus arundineus

Fig. 6. Pissonotus speciosus
Fig. 7. Pissonotus nigridorsum
Fig. 8. Delphacodes shermani

PLATE 2

Fig. 1. Pissonotus fulvus
Fig. 2. Euidella triloba
Fig. 3. Megamelus inflatus
Fig. 4. Delphacodes alexanderi
Fig. 5. Megamelus aestus
Fig. 6. Delphacodes campestris
Fig. 7. Megamelanus dorsalis
Fig. 8. Criomorphus conspicuus
Fig. 9. Delphacodes fulvidorsum
Fig. 10. Megamelus distinctus
Fig. 11. Megamelus uncus
Fig. 12. Delphacodes waldeni
Fig. 13. Megamelus anticostus

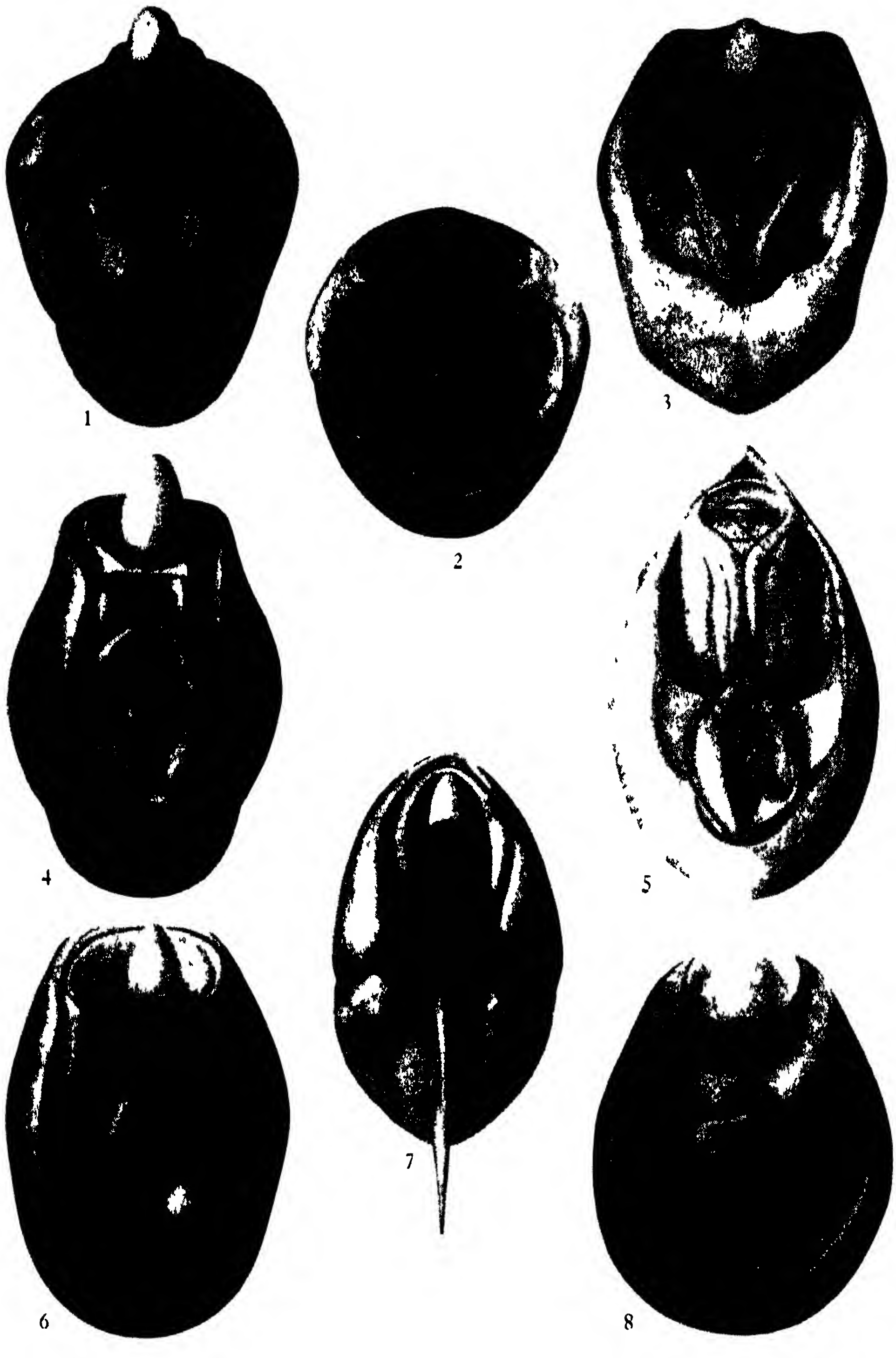
PLATE 3

Fig. 1. Delphacodes shermani
Fig. 2. Megamelus uncus
Fig. 3. Pissonotus speciosus
Fig. 4. Megamelus anticostus
Fig. 5. Euidella triloba
Fig. 6. Megamelus distinctus
Fig. 7. Delphacodes fulvidorsum

PLATE 4

Fig. 1. Stenocranus arundineus
Fig. 2. Megamelus aestus
Fig. 3. Delphacodes waldeni
Fig. 4. Pissonotus nigridorsum
Fig. 5. Delphacodes alexanderi
Fig. 6. Megamelanus lautus
Fig. 7. Delphacodes campestris
Fig. 8. Megamelanus dorsalis
Fig. 9. Criomorphus conspicuus
Fig. 10. Delphacodes staminata
Fig. 11. Euidella gerhardi
Fig. 12. Pissonotus fulvus
Fig. 13. Megamelus inflatus
Fig. 14. Megamelanus terminalis

PLATE 1



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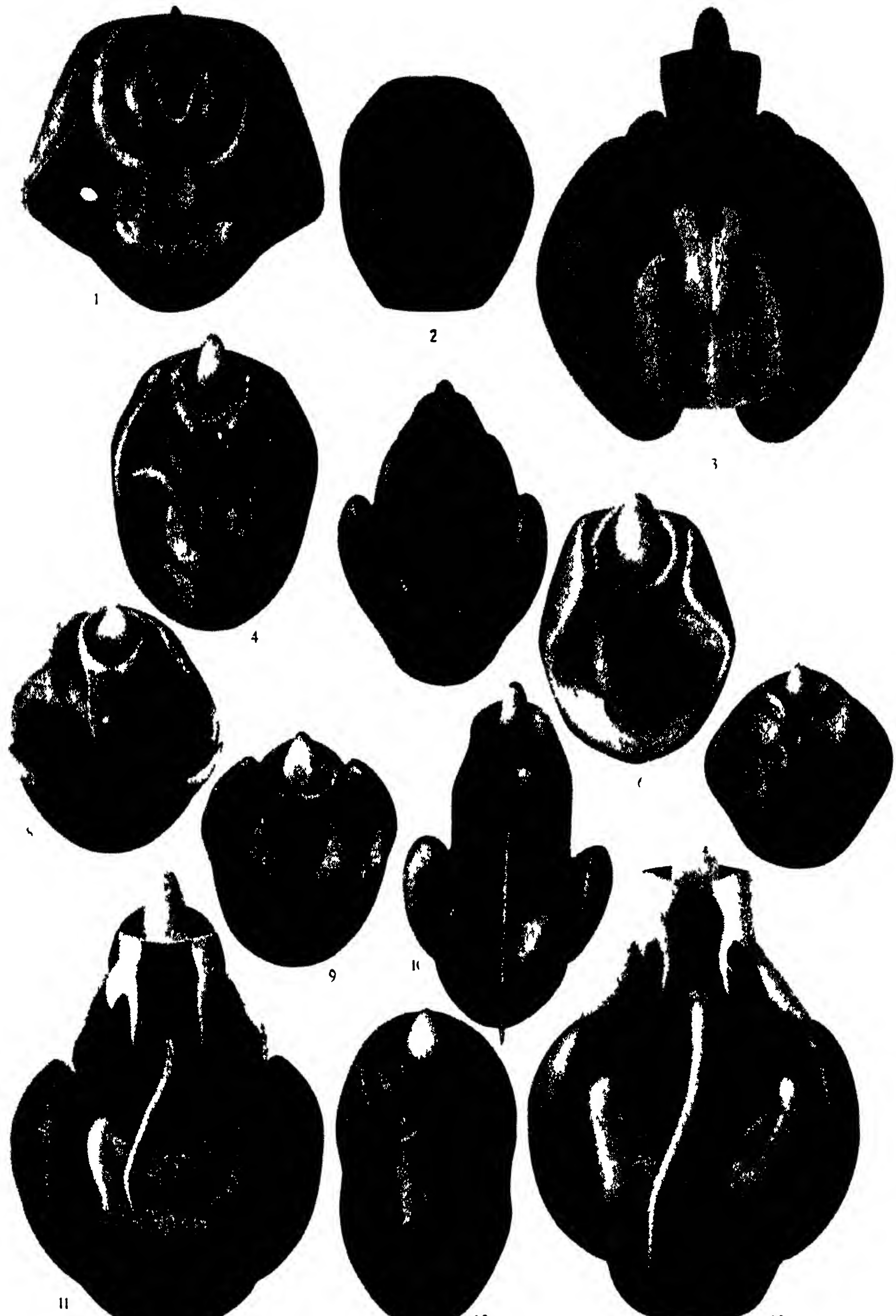

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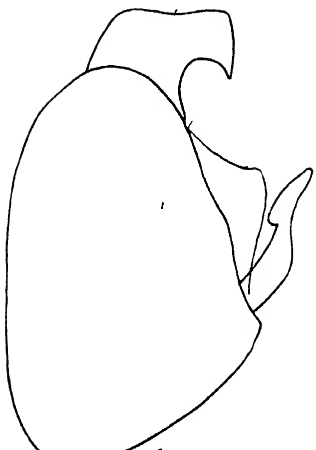

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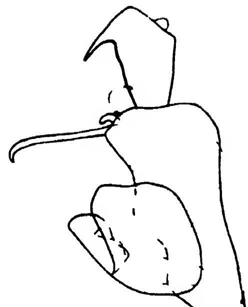

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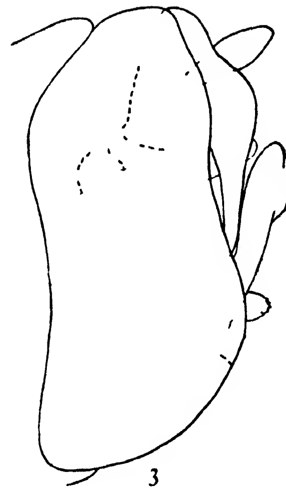

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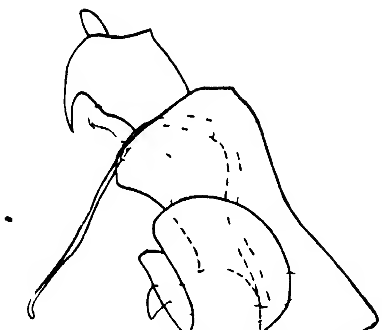

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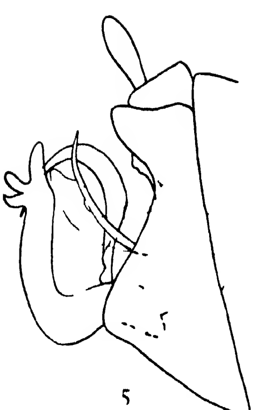

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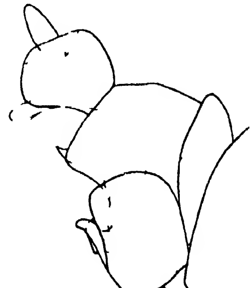

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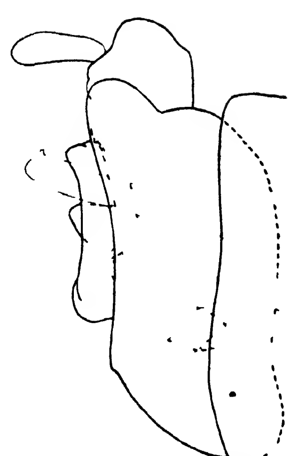

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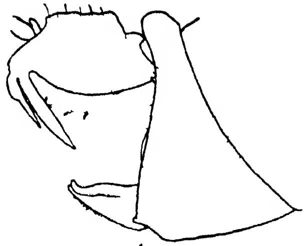
PLATE 4



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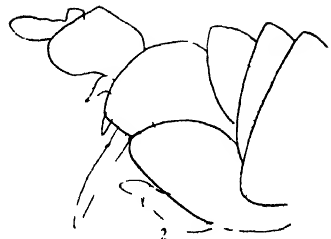

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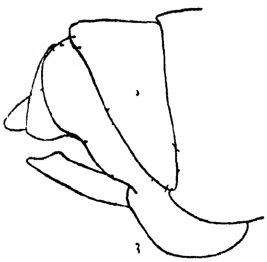

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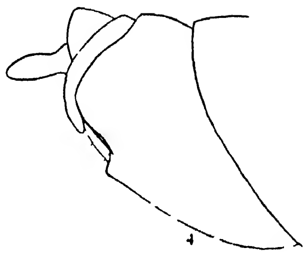

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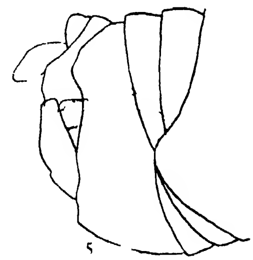

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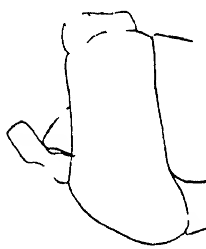

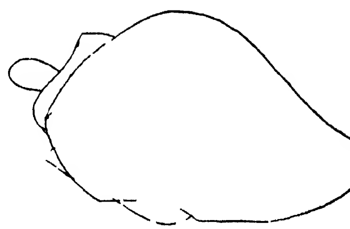

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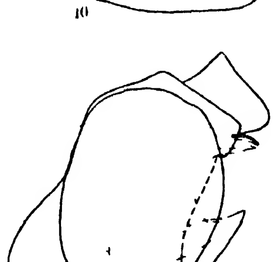

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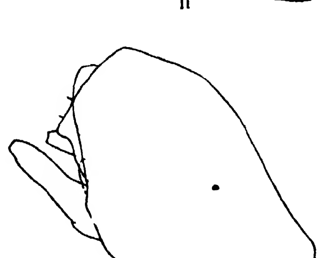

14

THE RELATION OF THE MIDGUT TO GROWTH AND DEVELOPMENT OF HABROBRACON, WITH A PERTINENT NOTE ON SPOROZOAN INFECTION

By Daniel S. Grosch

Department of Zoology and Entomology, N. C. State College of Agriculture and Engineering of the University of North Carolina
Raleigh, North Carolina

Plate 5 and 3 Text Figures

In a report of growth in the ecto-parasitic wasp known in genetic literature as *Habrobracon juglandis* (Ashmead) (see Martin, 1947) it was indicated that there are unique features of size increase in parasitic hymenopterous larvae (Grosch, 1948b). Chief among these is the expansible pouch-like midgut which occupies a strikingly large percentage of the larval volume. The present report supplies a summary of specific data in support of this statement and includes observations on mortality due to a sporozoan infection which may indicate the source of reserve materials used in metamorphosis.

MATERIALS AND METHODS

The eugenic wild type stock used in this investigation was reared in an incubator held at 28°C. Larvae of known age were obtained from eggs laid by females during the one-hour periods they were allowed to parasitize a given group of host caterpillars—the larvae of *Ephestia kuehniella* (Zeller). At a desired age (based on Grosch, 1948b) *Habrobracon* larvae were removed from the host, measured, and either dissected for immediate examination or fixed in Bouin's fixative for subsequent study.

Dissections to free the midgut were made in a drop of isosmotic insect Ringer's solution upon a microscope slide. When free in the Ringer's the midguts were measured using an optical micrometer.

Permanent slides were prepared from the fixed larvae by the paraffin method. Serial sections obtained were stained by Heidenhain's iron-hematoxylin method. These were studied under a compound microscope equipped with an ocular micrometer. In addition to furnishing the present results, the slides were useful in a study on the cytological aspects of larval growth (in press).

OBSERVATIONS AND RESULTS

Internal morphology of larvae.

In the present paper there are illustrations which should serve in orientation on the morphology of *Habrobracon* larvae. A scale diagram of a lateral view of a mature larva is given in figure 1 and plate 5 presents photographs of longitudinal sections of mature larvae. In addition, the published figure depicting a typical cross section of a mature larva may be consulted (Grosch, 1948b). As

shown in all representations, the most evident larval structure is the large midgut. This structure has only one opening, the valvelike inlet (Fig. 1, V) from the esophagus. The simple tube which is the esophagus leads from the pharynx, a structure with a wall heavily muscled (Fig. 1, M) which enables the pharynx to function as a pumping apparatus. The anterior end of the pharynx extends from the small buccal cavity.

At the posterior extremity of the midgut there is no opening although the anterior end of the hindgut (Fig. 1, HG) is closely proximate. Emptying into the hindgut at this point are the two malpighian tubules (Fig. 1, MT) which extend forward into the thoracic region, lying laterally yet relatively near each side of the ventral nerve cord.

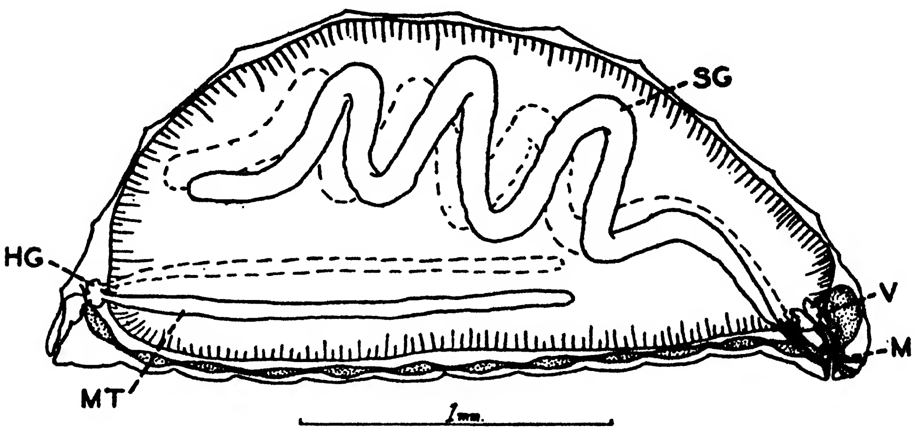

FIG. 1. Diagrammatic lateral view of the mature larval body plan in *Habrobracon juglandis*. Except for size relations this general plan also applies to younger larvae. The limits of the midgut are accentuated by short perpendicular lines. The elements of the central nervous system are stippled. Labels designate other important features as follows: HG = blind end of hindgut, MT = malpighian tubule, M = muscles of the wall of the pharynx, SG = spinning gland, V = valvelike inlet to midgut. Further description is given in the text.

Another pair of tubular structures found between gut wall and body wall are the spinning glands (Fig. 1, SG). These originate ventrally in the head region from a single tube which opens to the exterior by a fine canal on the upper border of the labium. They follow an undulating course laterally down the larva about as far as the posterior limits of the midgut.

The central nervous system is composed of a typically arthropod chain of ganglia which in cross section are seen to be a double arrangement of bilaterally symmetrical parts. These ganglia comprise the supra-esophageal brain and the ventral elements of the nerve cord (stippled in Fig. 1). The space between gut wall and body wall not occupied by tubular or nervous structures is packed with cells of the fat body, fine muscle fibers, and delicate tissues of the respiratory and circulatory systems. The fat cells are the most evident. The impression

of packing is gained from the fact that unlike most insect larvae the fat cells are arranged in only a single layer.

Enclosing and restricting the whole is the body wall, a layer of external cuticula backed by a single layer of epidermal cells except at locations of cellular masses which represent the anlagen of adult appendages.

Relative size of the midgut

Comparison and correlation between the sizes of larvae and of their midgut dimensions were made both in fresh dissections and with permanent slides of

TABLE 1

Measurements in millimeters at greatest dimension

LARVAE (BEFORE DISSECTION)		MIDGUTS (AFTER DISSECTION)		NUMBER
Length	Diameter	Length	Diameter	
.50	.18	.50	15	3
.60	.20	.60	20	5
.70	.25	.65	20	10
.70	.30	.70	.30	5
.70	.40	.70	.35	3
1.35	.60	1.25	.50	4
1.35	.65	1.35	.50	5
1.40	.60	1.35	.60	5
1.50	.60	1.45	.60	5
1.55	.60	1.50	.60	5
1.60	65	1.60	.60	5
1.65	.75	1.65	.75	1
1.70	.75	1.70	.75	3
1.75	.75	1.75	.75	1
1.82	.75	1.80	.75	2
1.85	.75	1.85	.75	1
1.90	.80	1.90	.80	5
2.25	.85	2.25	.85	2
2.30	.85	2.25	.85	1
2.42	.90	2.40	.90	5
2.50	1.00	2.50	1.00	2
2.65	1.05	2.60	1.00	5
2.75	1.10	2.60	1.05	5

sectioned material. Table 1 presents a series of midgut measurements along with comparable dimensions of larvae from which they were removed. The arrangement presented is based on the order of increase in larval size. Groups into which these data fall were determined by the timed selection of larvae and by the fact that with the lens system used the smallest ocular unit was equivalent to 0.05 mm. This type of data demonstrates that when freed of surrounding tissues the midgut approaches and sometimes even attains the dimensions of the larva from which it was removed. It implies that there is some expansion of the midgut when it is freed from the larval body. A direct demonstration of ex-

pansion can be provided by careful dissections of larvae taken just prior to a moult. Then if a slit is made in the epidermis with care not to puncture the midgut, the midgut will bulge out of and even emerge from the opening. In fact occasionally the entire midgut has actually expelled itself from such a slit.

There are no size differences nor are there larval sex characters whereby males can be easily distinguished from females especially in the early half of larval life. However under the conditions of the experiment at least 50% of the offspring should have been female.

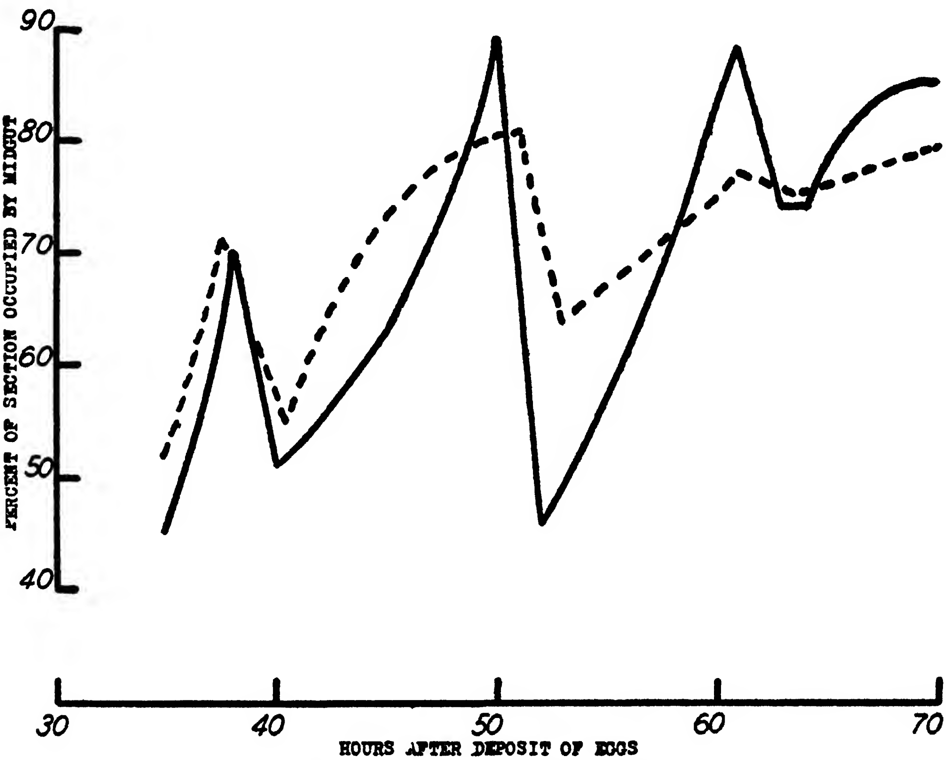

FIG. 2. The percentage of section occupied by the midgut during larval development of haploid Habrobracon. The broken line represents calculations from sagittal sections. The solid line represents calculations from transverse sections of the mid-abdominal region.

Mounted sections provide a basis for making a two-dimensional study of the sectional area occupied by the midgut while in place. After a preliminary survey of slides from larvae of mated females it was decided to restrict study for the time being to a group of offspring in which it would be known that all animals were of the same sex and thus perhaps more homogenous and useful in reference. Such a group of offspring was provided by the parthenogenetically produced males from unfertilized eggs. These offspring from virgin females breed as haploids and are known as haploid males.

A graphic summary of changes which show in sections of haploid larvae are

given in figure 2 by plotting the percentage of the larval section occupied by the midgut against age of the organism. Compared with evidence from transverse sections of 140 larvae, changes in percentage of longitudinal section occupied by the midgut are shown to be more moderate. However the curve with this latter information should be considered with reservation because of the smaller number of longitudinally sectioned larvae (40) on which it is based. Although a complete series is furnished by these longitudinal sections, the critical high points in the curve could have been missed if they are very abrupt in occurrence. Attempts to complete as large a series of longitudinally sectioned larvae as the transverse series were discontinued after a success of less than 40%. Technical difficulties in making longitudinal sections are traceable chiefly to the relatively large midgut.

When these results are compared with "growth" records given by Grosch (1948b) it is found that before each moult the midgut occupies a high percentage of the larval volume; near the beginning of each moult the relative volume occupied by the midgut falls to a low followed soon by an upswing. During the third moult the low percentage occupied by the midgut is not as low as during the two preceding moults. The measurements on which the percentage values are based indicate that it is a change in size of the area occupied by tissues surrounding the midgut which is reflected in the rhythmic curves. The tissue layers appear looser and the individual structural elements seem larger while the midgut shows no more than its usual incremental increase in size. The fact that the amount of actual larval tissue is relatively small by the third moult and cannot contribute much change by its "expansion" is consistent with the failure of relative midgut volume to drop to as low a percentage at the third moult as at other moults.

Increase in larval size which may be due to an "expansion" at the time cuticular restraint is at a minimum has not been distinguishable from the general process of size increase. No sudden changes in size have been observed in studying external dimensions during the period when changes in the ratio of midgut/larva volume are taking place. Imperceptible merging of these with the more general processes undoubtedly complicate the growth curves. Perhaps on this basis may be explained a failure of "breaks" in width curves (later) to correspond with the times of "breaks" in length curves (earlier) (see Grosch, 1948b).

Gut contents and size increase

Examination of fresh preparations discloses that the lumen of the midgut of *Habrobracon* larvae normally contains globules of fat (preferentially stainable with Sudan dyes) and small pieces of host tissue in fluïd suspension. When this material is subjected to the solvents used in the paraffin method the fat globules dissolve to leave the fixed suspending fluid as an alveolar artifact (Figure 4). The host tissue fragments, chiefly muscle, do not appear in the midgut contents until the last larval stage unless the host caterpillar is small originally or depleted by the simultaneous feeding of too many other parasites.

Usually, sick host caterpillars can be detected by their appearance and dis-

carded. However in an exceptional case permanent slides were prepared for three *Habrobacon* larvae of a group of five from a diseased host which showed no external signs of illness. Figure 5 presents a photograph of a longitudinal section through one of these larvae. It can be seen that in this case the gut contents are composed chiefly of spores. No organized tissue remnants or alveolar indications of fat globules are visible in the gut lumen. Figure 3 gives an enlarged camera lucida drawing of one of the spores ($13.2 \times 7.2\ \mu$) which shows internal detail. In many other spores, which presumably are more mature, it is difficult to demonstrate the nucleus. Morphologically these spores resemble those of the microsporidian, *Stempellia magna* Kudo (Kudo, 1924) more closely than any of the other species described in available literature. *Stempellia magna* is typically obtained from the fat bodies of various culicine larvae.

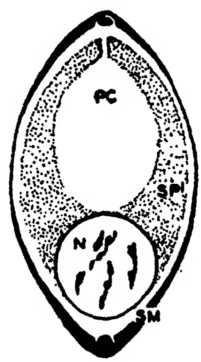

FIG. 3. Camera lucida drawing of a spore with discernible internal structure: N = nucleus, PC = polar capsule, SM = spore wall, SP = sporoplasm.

It is interesting that in spite of their abnormal gut contents the *Habrobracon* larvae showed normal increase in size per unit time. Thus there was no apparent difficulty in the performance of larval functions. The time of spinning and the construction of cocoons seemed normal for the two larvae which were allowed to remain on what is now known to have been a heavily infected host. However, they failed to metamorphose.

DISCUSSION

The internal morphology of *Habrobracon* larvae is very similar to that described for other braconids (refer to the series of papers cited in Grosch, 1948b). A very evident midgut present as a blind sac seems characteristic of all hymenopterous larvae. This type of digestive system has been considered a suitable adaptation to the highly nutritious food hymenopterous larvae normally take or are fed (Carpenter, 1928, p. 183). In the majority of Hymenoptera, however, the midgut occupies only 33% or less of the larval body which is a small volume compared to the values seen in *Habrobracon* larvae. In parasitic Hymenoptera such an extremely large larval midgut seems to be a further adaptation needed

for quick intake and storage of materials which are likely to deteriorate and for which there is competition with other larvae. This was inferred by Seurat as early as 1899. However during intervening years the significance of the large midgut has had little emphasis in spite of frequent descriptions of its presence. Along with the author's 1948b contribution the present report should serve to redirect attention to the importance of the midgut in braconid biology, especially since differences in storage can partially explain the relation between dwarfism and determinate cell size (Grosch, 1948a).

Furthermore, other considerations which extend the importance of the midgut seem indicated. The development of internal pressure reported herewith seems attendant on the forcing of ingested host material into the blind midgut through a one-way valve. In turn, larval increase in size can be related to the intake in the amount of non-living material which is added to the accumulation already in the gut lumen. Substances merely ingested are in actuality not within the physiological interior of the organism, yet, since the lumen of the midgut occupies the significant volume of the larva, it is evident that when one measures larvae at subsequent times in order to make "growth" comparisons, actually it is the amount of non-living—and therefore non-growing—contents added since the last observation which are providing much of the change observed. This of course depends on the pumping action of the foregut and the availability of ingestible materials. Such details seem to explain how *Habrobracon* larvae increase 5 times in length and 7 times in width during less than 40 hours while most other nonparasitic insects take days instead of hours to accomplish comparable increases.

If the normal size and appearance of larvae which ingested chiefly microsporidian spores are considered, it seems evident that only a small fraction of the ingested materials is used to support larval development. Judging from the histological appearance of tissues on serial sections the internal larval structure is entirely normal. There was even no sporozoan invasion of the midgut wall. Nevertheless, death occurred when the two pupated organisms failed properly to undergo metamorphosis. Presumably they differed from equivalent haploids only in their midgut contents—spores instead of fat globules. It seems significant that these two were the only haploid males of this stock which died in the cocoon during the time that the stock was under observation. Such facts along with what is known of metamorphosis in other insects points to a hypothesis that braconids rely on the contents of the midgut rather than on the larval tissues for reserve materials in metamorphosis. As a matter of fact, a mature *Habbrobracon* larva *has* very little larval tissue proper. Except during a moult the living larval tissue comprises strikingly thin layers compressed between midgut and body wall (Fig. 4, Plate 5).

It is not intended that only two specimens be used to justify a generalization. There are situations to which the present is a parallel. These occur in other insects which follow the more common procedure of drawing on the fat body during the histogenesis involved when a holometabolous insect changes to its adult form. Mattes (1928) describes such parallel situations in his discussion of

the pathology of microsporidia in definitive hosts. He indicates that many genera of microsporidia are typically fat body parasites. During larval development, in spite of a great invasion of the fat body, the effect on the outward appearance of infected larvae is small. However the infected larvae cannot develop into normal imagos because the fat body which plays an important role by providing reserves in metamorphosis is not available. It is found therefore that most of the pupae are inviable. Those imagos which do manage to develop from infected larvae show structural abnormalities and are infertile.

Although inferences may be drawn as to what occurs when only a few spores are ingested by a *Habrobracon* larva, the present paper throws no direct light upon the question of the wasp as a vector of sporozoan disease considered in a note by Payne (1933). It is difficult to see how a heavy infection of the present sporozoan can be maintained and transmitted when it results in the death of the potential vector.

SUMMARY

1. The internal morphology of *Habrobracon juglandis* larvae is described.

2. The midgut which is the most evident larval structure is shown by dissection to approach the size of the larva and if observed just prior to a moult, the freed midgut may even expand to the dimensions of the larva which once enclosed it.

3. A study of a series of sectioned haploid male larvae (used to provide a homogenous sample) shows that just before a moult the midgut occupies a very large percentage of the larval volume while during a moult this value falls. This is especially evident during the first two moults.

4. Normally the midgut contents of mature larvae consist of fat globules and a few muscle fragments in liquid suspension. Sectioned larvae from a host (*Ephestia*) infected with a sporozoan parasite showed chiefly spores as the midgut contents. The group had shown normal size increase per unit of time and undisturbed larvae remaining on the same host entered cocoons normally. However they were unable to metamorphose. It seems indicated that braconids rely on a midgut storage of reserves for metamorphosis rather than carry out the more common mode of insect procedure, that of utilizing the fat body.

5. The sporozoan parasite resembles *Stempellia magna* Kudo, a microsporidian usually described from the fat-bodies of culicine larvae.

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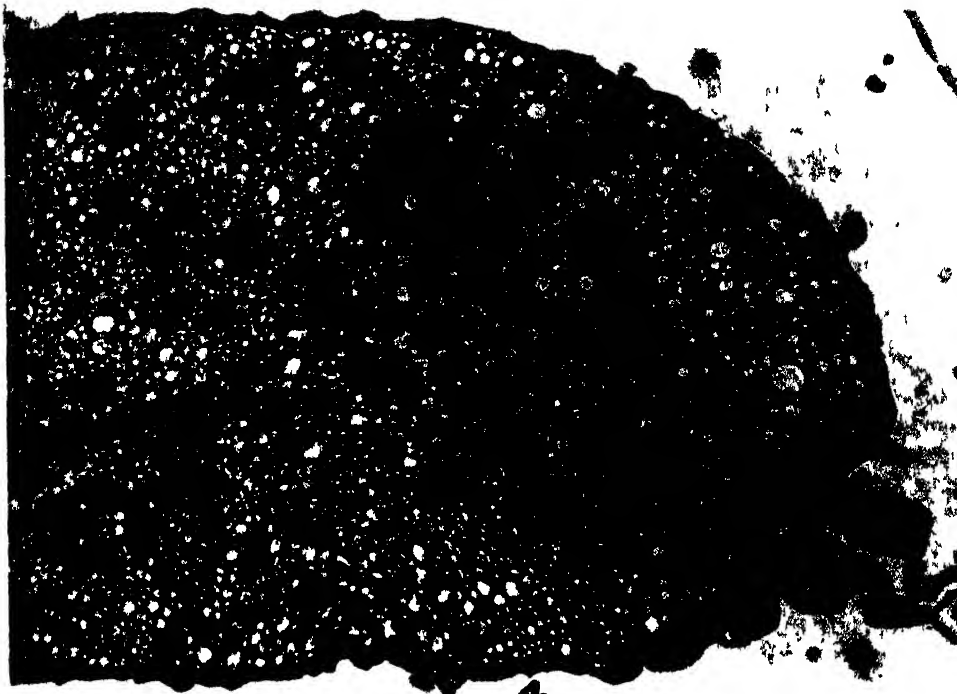
PLATE 5

Photographs by Sturgis McKeever (× 80)

FIG. 4. Posterior of a mature Habrobracon larva in sagittal section showing typical large midgut and normal contents of the lumen. Scattered dark areas in the midgut contents are deeply stained muscle fragments.

FIG. 5. Anterior of a mature Habrobracon larva in near sagittal section showing typical large midgut filled with atypical contents. The dark bodies are microsporidian spores. The spread larval tissue, an aid to cytological examination, is an artifact produced by applying pressure to the cover after mounting.

PLATE 5



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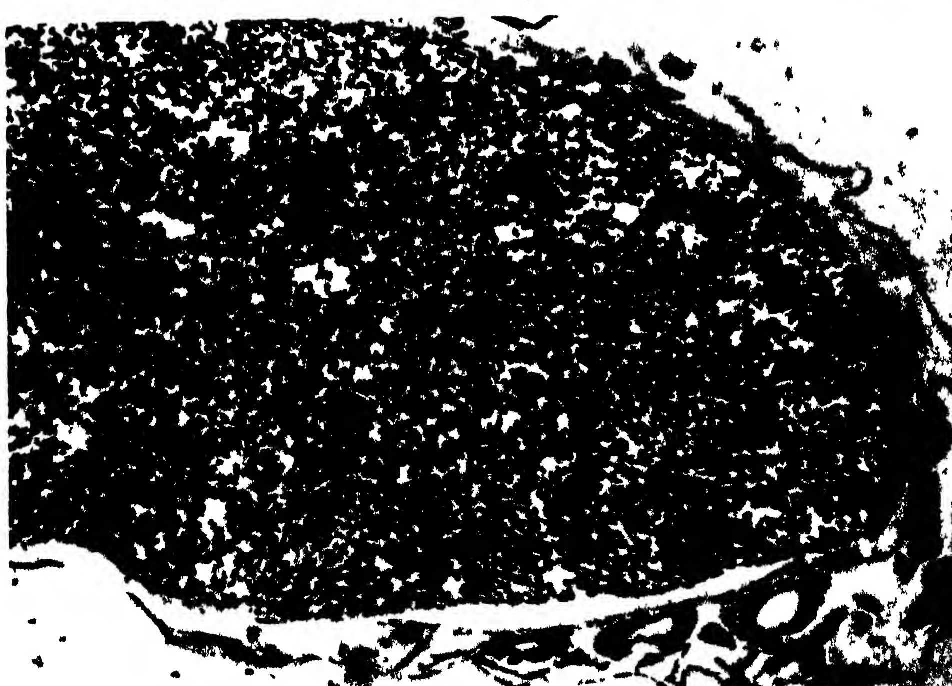

5

THE MYXOPHYCEAE OF NORTH CAROLINA[1]

By Elton C. Cocke

Department of Biology, Wake Forest College
Wake Forest, North Carolina

Until only recently the Myxophycean Flora of the southeastern states has been very inadequately represented in the literature and herbaria. This was especially true for North Carolina, from which only fourteen species of blue-green algae had been reported prior to 1938. Ravenel in 1877 reported *Scytonema myochrous*; Smith in 1880 reported *Scytonema figuratum* from Warren Springs; Green in 1897 described *Nostoc sphaericum* from Tryon; Stevens in 1908 reported *Porphyrosiphon Notarisii* from Raleigh; and Hoyt in 1917 included ten species of Myxophyceae in his paper on the algae of Beaufort and adjacent areas. In 1938 Drouet checked and published an account of ten specimens collected by Dr. Lewis David von Schweinitz in and around Winston-Salem about 1812.

The first attempt at a systematic study of the Myxophyceae of North Carolina was made by Paul Philson, who published a report on the Cyanophyceae of North and South Carolina in 1939. The results published in this paper were from the findings gathered from a limited number of collections made in a restricted area around Durham. In 1943 L. A. Whitford published an annotated list of "The Fresh-water algae of North Carolina." In this paper he reported all species previously reported from the state, including those listed by Leatherwood in his master thesis at Wake Forest College in 1942. In addition, he added a goodly number of new forms from his own investigation. The total number of species of blue-greens reported by Whitford was one hundred twenty-nine. Blomquist and Humm added nine additional species in 1946, Williams added four more in 1948, and Silva reported one new form. Thus the total number of species which has been recorded to date is 139 (two listed by Leatherwood have been omitted and two others changed because of incorrect identification). Dr. Harold Bold has collected a number of forms in the mountains of North Carolina and Mr. Herman Silva has made limited collections in this area. The author is indebted to Mr. Silva for the records of his and Dr. Bold's collections.

Although this study of the Myxophyceae of North Carolina has been under way since 1939, little was accomplished until 1947. During this time more than two thousand collections extending over most of the state have been made.

The following annotated list includes all species of Myxophyceae which have been reported from North Carolina and, in addition, 136 forms which have not previously been recorded for the state.

[1] The author is grateful for the following research funds which have stimulated and made possible this investigation: grants from the Carnegie Research Fund for the Improvement of Teaching, grants from the A. A. A. S. through the North Carolina Academy of Science, felllowship from the University of North Carolina, and the Margaret Cannon Howell Fellowship from the Highlands Biological Laboratory.

The abbreviations WFC, Wake Forest College; UT, University of Tennessee; and CM, Chicago Museum after the name of a specimen indicates that herbarium specimens are to be found in these places.

CYANOPHYTA

Class **Myxophyceae**

ORDER 1 CHROOCOCCALES

FAMILY 1. *Chroococcaceae*

Chroococcus decorticans A. Braun.
On walls of dams, spillways, and watering troughs. Haywood Co. (Leatherwood), Johnston, Guilford, Warren, Macon, and Jackson Cos. Spring and Summer. WFC #165.

C. dispersus (V. Keissler) Lemmermann.
Plankton. Wayne Co. (Whitford). June.

**C. giganteus* W. West.
Mountains of North Carolina (Bold #95).

C. limneticus Lemmermann.
Widespread and abundant in plankton of small ponds and lakes in Coastal Plain (Whitford). WFC #218. Spring and summer.

**C. macrococcus* (Kuetz.) Rabenhorst.
On dripping rocks, Dry Falls, Macon Co. WFC #273. August.

C. minutus (Kuetz.) Naegeli.
In plankton and mixed with other algae. Wake Co. (Whitford), Lee, Macon Cos. WFC #212. Summer.

C. multicoloratus Wood.
On wooden spillway. Haywood Co. (Leatherwood). August.

C. pallidus Naegeli.
On wet rocks and in old bottles. Wake Co. (Leatherwood), Macon Co. WFC #207. Spring and summer.

**C. refractus* Wood.
Under a dripping spigot at a service station. Carteret Co.

C. turgidus (Kuetz.) Naegeli.
Shallow pools and wet soil. Mountains of N. C. (Bold), Durham Co. (Philson), Coastal Plain (Hoyt, Whitford). WFC #246. Common at all seasons.

**C. Turicensis* (Naeg.) Hansgirg.
On submerged sticks and weeds in lake in city park, Wilmington. New Hanover Co. WFC #247. Summer.

C. varius A. Braun.
Dripping rocks, spillways, and concrete dams. Haywood Co. (Leatherwood), Macon Co. WFC #279. Summer.

* Reported for the first time in North Carolina.

**Gloeocapsa alpicola* (Lyng.) Bornet.
Mountains of N. C. (Silva, CM).

**G. arenaria* (Hassall) Rabenhorst.
Forming scum on flower pots and on wet rocks. Edgecombe and Macon Cos. WFC #302. Summer.

G. conglomerata Kuetzing.
On damp ground in greenhouse, spillways, and dams. Durham Co. (Philson), Wake, Alamance, Caswell Cos. WFC #123.

**G. decorticans* (A. Braun) P. Richter.
On damp soil and bridge footings. Pasquotank, Johnston, Orange, and Wake Cos. WFC #150.

**G. fenestralis* Kuetzing.
On wet boards under the mill at Moore's Mill. Franklin Co. WFC #101. June.

**G. granosa* (Berk.) Kuetzing.
On seeping rocks at Moore's Mill. Franklin Co. WFC #120. June.

**G. magma* (Bréb.) Kuetzing.
Forming a brownish coating on wet rocks. Mountains of N. C. (Bold), Macon Co. WFC #280. August.

**G. nigrescens* Kuetzing.
Mountains of N. C. (Bold #91).

**G. polydermatica* Kuetzing.
On wet beams under dam at the golf course pond, Highlands. Macon Co. WFC #292. August.

G. sparsa Wood.
On dripping rocks. Durham Co. (Philson).

Aphanocapsa delicatissima W. and G. S. West.
Plankton. Lenoir Co. (Whitford). June.

A. elachista W. and G. S. West.
Plankton. Cumberland Co. (Whitford). May.

A. Grevillei (Hassall) Rabenhorst.
Plankton. Durham Co. (Philson), Edgecombe Co. WFC #190. June.

A. pulchra (Kuetz.) Rabenhorst.
In small pools. Bladen and Craven Cos. (Whitford). Spring.

Microcystis aeruginosa Kuetzing.
Common in ponds and pools at all seasons (Whitford). Nash, Wake, Franklin, Dare, Hyde, and New Hanover Cos. WFC #123.

**M. ichthyoblabe* Kuetzing.
Plankton in Wake Forest College Golf Pond. Wake Co. WFC #123. June.

**Anacystis firma* (Kuetz.) Drouet and Dailey.
Mountains of N. C. (Bold).

**A. marginata* Meneghini.
Mountains of N. C. (Bold #156, 158).

**Diplocystis incerta* (Lemm.) Drouet and Dailey.
Mountains of N. C. (Silva).

**Merismopedia aeruginea* Brébisson.
On wet soil. Moore Co. WFC #211. July.

M. elegans A. Braun.
In plankton widely distributed throughout the state (Whitford). WFC #156. Summer.

M. glauca (Ehrenb.) Naegeli.
Wake and Bladen Cos. (Whitford), Washington, Pasquotank Cos. WFC #149, 189. Summer.

M. maior (G. M. Smith) Geitler.
Small pond. Wake Co. (Whitford). February.

M. punctata Meyen.
Small ponds. Bladen and Hyde Cos. (Whitford), Dare Co. WFC #176. May.

M. tenuissima Lemmermann.
Plankton. Wake Co. (Whitford). Spring and fall.

**Holopedium irregulare* Lagerheim.
Mountains of N. C. (Bold #16).

Synechococcus aeruginosus Naegeli.
Among wet mosses where water seeps from hillside. Wake Co. (Whitford). Along edge of fishpond. Cumberland Co. WFC #235. Spring and summer.

**S. Cedrorum* Sauv.
On dripping rocks. Macon and Clay Cos. WFC #272. August.

**S. racemosus* Wolle.
On wet soil in greenhouse at University of North Carolina. Orange Co. WFC #191. June.

**Gloeothece confluens* Naegeli.
On moist earth and in small pools. Wake Co. WFC #233. Summer.

**G. lunata* W. and G. S. West.
In drainage ditch. Pitt Co. WFC #125. June.

G. membranacea (Rabenh.) Bornet.
On wooden spillway. Haywood Co. (Leatherwood). August.

G. rupestris (Lyng.) Bornet.
In ponds among filamentous algae. Carteret and Cumberland Cos. (Whitford). Spring.

**Dactylococcopsis mucicola* Hustedt.
Plankton from millpond near Wilson. Wilson Co. WFC #276. July

**D. rhaphidioides* Hansgirg.
In cooling trough at City Ice Plant, Wake Forest. Wake Co. WFC #116.

**Aphanothece Castagnei* (Bréb.) Rabenhorst.
In pond with *Spirogyra*. Franklin Co. WFC #119. June.

A. conferta Richter.
On dripping rocks. Durham Co. (Philson), Macon Co. WFC #282.

**A. microscopica* Naegeli.
On face of wet rocks. Johnston and Jackson Cos. WFC #304. July and August.

A. pallida (Kuetz.) Rabenhorst.
A wet mass in Duke Greenhouse. Durham Co. (Philson).

**A. saxicola* Naegeli.
Collected in plankton net. Wake and Chowan Cos. WFC #133. June and July.

**A. stagnina* (Sprengel) A. Braun.
On dripping rocks. Mountains of N. C. (Bold); Macon Co. WFC #300. August.

**Coelosphaerium Kuetzingianum* Naegeli.
On submerged rocks in pasture. Stanly Co. WFC #262. July.

C. Naegelianum Unger.
Plankton of ponds and springs. Widespread in Piedmont and Coastal Plain. (Whitford). Spring and fall.

Gomphosphaeria aponia var. *delicatula* Virieux.
From one bog pond. Craven Co. (Whitford). June.

G. lacustris Chodat.
Apparently widespread in the Coastal Plain plankton in spring and summer. (Whitford).

Family 2 *Entophysalidaceae*

Entophysalis granulosa Kuetzing.
On sand on surface of exposed peat above high water, Harker's Island. Carteret Co. (Blomquist, Williams). August.

**E. cornuana* Sauv.
Mountains of N. C. (Recorded by Silva). CM.

Order 2 CHAMAESIPHONALES

Family 1 *Pleurocapsaceae*

Hyella caespitosa Bornet and Flahault.
On oyster shells with *Calothrix crustacea*, Piver's Island. Carteret Co. (Blomquist, Williams). August.

Family 2 *Chamaesiphonaceae*

**Chamaesiphon filamentosus* Ghose.
Mountains of N. C. (Silva #200).

C. incrustans Grunow.
Epiphytic on aquatic mosses and algae. Wake Co. (Whitford, Leatherwood). Winter and spring.

Order 3 HORMOGONALES

Sub-order 1 HOMOCYSTINEAE

Family 1 *Oscillatoriaceae*

Spirulina laxa G. M. Smith.
Small pond. Wake Co., brackish pool. Carteret Co. (Whitford). Winter and spring.

S. major Kuetzing.
In sluggish drain ditch with *Oscillatoria*. Wake Co. (Whitford); along the coast (Williams), Monroe, Union, and Moore Cos. WFC #255. Summer.

S. princeps West and West.
Floating in ponds in Piedmont and Coastal Plain (Whitford). Summer.

S. subsalsa Oersted.
On brackish beach sand and exposed peat. Harker's Island. Carteret Co. (Blomquist). March and August.

**Arthrospira Jenneri* (Kuetz.) Stizenberger.
Collected in plankton net. Washington and Beaufort Cos. WFC #169. June.

**Oscillatoria acuminata* Gomont.
Ponds and sluggish streams. Edgecombe, Johnston, Guilford Cos. WFC #157. June.

O. amoena Gomont.
Slow streams, ponds, and lakes. Haywood Co. (Leatherwood) Lenoir, Wake, and Macon Cos. WFC #290. Summer.

O. amphibia Agardh.
Widespread in small streams and ponds. Wake and Franklin Cos. (Leatherwood). WFC #114. All seasons.

**O. anguina* Bory.
Floating in a small rock pool at Mitchell's Mill. Wake Co. WFC #113. June.

**O. angustissima* W. and G. S. West.
On submerged logs and boards. Pasquotank, Perquimans, and Guilford Cos. WFC #138. June.

**O. brevis* Kuetzing.
Mixed with other algae in tanks at Carolina Biological Supply Co. Guilford Co. WFC #171. Summer.

O. chalybea Mertens.
Scum on a swampy pool. Wake Co. (Whitford). March.

**O. chlorina* Kuetzing.
Along the water edge of a small stream. Lenoir Co. WFC #170.

O. formosa Bory.
Abundant and widespread throughout the Piedmont and Coastal Plain on mud and moist earth (Leatherwood). WFC #106.

O. geminata Meneghini.
Floating. Wake Co. (Leatherwood), Chowan, Camden, Johnston Cos. WFC #134. Summer.

O. lacustris (Kleb.) Geitler.
Shallows of mill pond. Harnett Co. (Whitford).

O. limosa Agardh.
On moist soil. This form was first collected by Dr. Lewis D. von Schweinitz in Forsyth Co. about 1812. Drouet examined von Schweinitz's collections and described them in 1938. Haywood Co. (Leatherwood), McDowell Co. (Philson), Wake, Franklin, and Lincoln Cos. Summer.

O. Meslini Frémy.
Bottom of brook. Wake Co. (Whitford). April.

**O. minnesotensis* Tilden.
On dripping rock below a dam. Chatham Co. July.

O. nigro-viridis Gomont.
"Epiphytic on various algae growing in entangling masses. Perennial but most common in the fall" (Williams).

**O. numidica* Gomont.
In a small pool below a mill pond dam. Wayne Co. WFC #238. July.

O. princeps Vaucher.
Common in sluggish streams and ponds throughout the state (Philson, Leatherwood). WFC #123, 204. All seasons but more abundant in warm weather.

**O. proboscidea* Gomont.
Along the edge of the water in Little River. Pasquotank Co. WFC #150. Summer.

O. prolifica (Grev.) Gomont.
In a wooden spillway. Haywood Co. (Leatherwood). August.

O. sancta (Kuetz.) Gomont.
Abundant in Coastal Plain (Whitford). On flower pots in greenhouse. WFC #166. Summer.

O. splendida Greville.
Common and widespread throughout the state. (Leatherwood). WFC #118. All seasons.

O. subuliformis Gomont.
Attached to New River Lighted Whistle Buoy (Humm). This form is rare in North America. August 21, 1944.

O. subtilissima Kuetzing.
Floating in ponds and slow streams. Wake Co. (Leatherwood), Lee Co. WFC #210. August–October.

O. tenuis Agardh.
Probably the most abundant and widely distributed blue-green in North Carolina. Very common and abundant in slow streams and ponds. (Leatherwood, Whitford, Philson). WFC #126. All seasons.

O. tenuis v. tergestina.
In a small pool, Shackleford Banks. Carteret Co. (Blomquist).

O. Williamsii Drouet.
"On branches of *Pennaria tiarella* (Ayres) 4 ft. below mean low tide level on the protected side of the rocks of the jetty" (Williams). Summer.

Phormidium angustissimum W. and G. S. West.
On the mud bottom of a small stream. Durham Co. (Philson).

P. autumnale (Agardh) Gomont.
"On staircase of barhouse" (von Schweinitz, 1812. Identified by Drouet). Forsyth Co. Widely distributed throughout the state on moist soil and mud (Whitford). WFC #107, 140. Occurs during the entire year but much more abundant in the warmer months.

P. Corium (Agardh) Gomont.
On rocks and mud by small stream. Durham Co. (Philson), Rowan, Mecklenburg, and Union Cos. WFC #206. Summer.

P. crouani Gomont.
In patches on water soaked soil. Durham Co. (Philson).

P. favosum (Bory) Gomont.
Common in standing water (von Schweinitz—1812—identified by Drouet), Durham Co. (Philson), Wake Co. (Leatherwood), Forsyth, Nash, Scotland Cos. WFC #164. Summer.

P. inundatum Kuetzing.
Rare on stones in springs." Forsyth Co. (von Schweinitz, identified by Drouet). Mountains of N. C. (Bold #12).

**P. molle* (Kuetz.) Gomont.
On wet soil. Warren Co. WFC #108. June.

**P. naveanum* Grunow.
Floating at edge of lake. Edgecombe Co. WFC #136. June.

**P. papyraceum* (Agardh) Gomont.
On wet soil by a well in a pig pasture. Rockingham Co. Mountains of N. C. (Bold). CM. WFC #181.

P. Retzii (Agardh) Gomont.
Floating and growing in masses on mud. Forsyth Co. (von Schweinitz, described by Drouet), Franklin Co. (Leatherwood), Durham Co. (Philson). Widespread. WFC #105. Spring, summer, and fall.

P. subfuscum Kuetzing.
On submerged log. Wake Co. (Leatherwood). Spring.

**P. tenue* (Menegh.) Gomont.
In concrete pipe through which water was running. Lee Co. Recorded by Silva from mountains of N. C. WFC #195. July.

**P. tinctorium* Kuetzing.
Mixed with other algae. Guilford Co. WFC #171. June.

P. uncinatum (Agardh) Gomont.
On wet rocks. Forsyth Co. (von Schweinitz, described by Drouet), Wake Co. (Leatherwood, Whitford). Spring.

P. Valderianum (Delp.) Gomont.
On wet rocks. Franklin Co. (Leatherwood). Spring.

Lyngbya aerugineo-caerulea (Kuetz.) Gomont.
Common on mud. Durham Co. (Philson). Widely distributed in Piedmont and Coastal Plain. WFC #111. All the year.

L. aestuarii (Mertens) Liebman.
On mud and moist earth along streams. Durham Co. (Philson).

L. Birgei G. M. Smith.
In a slow stream. Wake Co. (Leatherwood). Spring.

**L. digueti* Gomont.
Edge of watering trough and on flower pots. Mountains of N. C. (Bold); Caswell, Rockingham, Orange Cos. WFC #182. Along the coast (Williams). Spring and summer.

L. ferruginea G. S. West.
Common and widely distributed in stagnant pools. Wake Co. (Leatherwood). Very frequently encountered in Piedmont and Coastal Plain. WFC #104. Entire year.

L. inflexa Frémy.
"Collected once in a decomposing algal mat in early August" along the coast (Williams). August.

**L. Lagerheimii* (Möbius) Gomont.
Abundant in ponds, lakes, and slow streams. Common in all of Piedmont and Coastal Plain. WFC #123. Spring and summer.

**L. lutea* (Agardh) Gomont.
Common on sand along the beach. Dare Co. WFC #151. June.

**L. major* Meneghini.
On damp soil near the river. Mountains of N. C. (Bold), Johnston Co. WFC #162. June.

L. majuscula (Dillwyn) Harvey.
Large mass adrift. Cape Lookout (Humm). September 20, 1941.

L. Martensiana Meneghini.
Submerged rocks and mud. Common in Piedmont and Coastal Plain areas (Whitford, Leatherwood). WFC #102. All the year.

L. nana Tilden.
In an old bottle on the dump, in stagnant pools. Wake Co. (Leatherwood), Wayne, Warren, Halifax Cos. WFC #215.

L. ochracea (Kuetz.) Thuret.
On moist earth and in ponds. Forsyth Co. (von Schweinitz, described by Drouet). WFC #123. Spring and summer.

**L. penicillata* Kuetzing.
On submerged concrete. Rowan and Halifax Cos. WFC #172. July.

**L. putealis* Montagne.
On mud. Caswell Co. WFC #177. June.

**L. semiplena* (C. Agardh) J. Agardh.
On wood exposed at low tide. Dare Co. WFC #143. June.

**L. spirulinoides* Gomont.
On face of concrete dam. Johnston Co. WFC #162. June.

**L. subtilis* W. West.
In a cemetery urn, laboratory jar, and on dripping rocks. Lee, Wake, and Macon Cos. WFC #272. July–August.

Porphyrosiphon Notarisii (Menegh.) Kuetzing.
On moist earth. Forsyth Co. (von Schweinitz, described by Drouet), Wake Co. (Stevens, 1908; Leatherwood). Common in the Piedmont counties. Spring.

Symploca borealis Rabenhorst.
Common on wet soil in early spring. Wake Co. (Leatherwood), Franklin, Granville, Macon, Jackson, Clay, and Chatham Cos. WFC #281. Spring and summer.

**S. dubia* (Naeg.) Gomont.
On moist soil by an old well. Rockingham Co. WFC #185. June.

S. muralis Kuetzing.
On moist soil. Swain Co. (Silva), Hoke Co. WFC #237. Summer.

**S. Muscorum* (Agardh) Gomont.
On moist soil under an outdoor water spigot under shed of an abandoned filling station, Roxboro. Person and Wake Cos. Mountains of N. C. (Bold #343). WFC #179. Summer.

**S. Willei* Gardner.
Base of tree trunks and on moist earth. Wake and Macon Cos. WFC #271. Summer.

**Microcoleus annulatus* F. E. Fritsch.
Forming patches on well packed mud along edge of Lake Asheboro. Randolph Co. WFC #260. July.

M. chthonoplastes (Flora danica) Thuret.
On moist soil both in fresh and brackish conditions. Dare Co. (Hoyt), Wake Co. (Leatherwood), Dare and Currituck Cos. WFC #151. Spring and summer.

M. lacustris (Rabenh.) Farlow.
Common on moist soils and in shallow ponds. Wake Co. (Leatherwood, Whitford). Found in most of the Coastal Plain counties. WFC #110. Common from early spring to late fall.

**M. paludosus* (Kuetz.) Gomont.
On moist soil along Cedar Creek. Jackson Co. WFC #307. August.

**M. sociatus* W. and G. S. West.
On mud and submerged sticks and vegetation. Perquimans, Rowan, Montgomery, and Gaston Cos. WFC #209. Summer.

**M. subtorulosus* (Bréb.) Gomont.
Found growing on concrete footings, moist soils and rocks. Warren and Macon Cos. WFC #285. Summer.

**M. tenerrimus* Gomont.
On soil exposed at low tide. Dare Co. WFC #151. June.

M. vaginatus (Vaucher) Gomont.
Common on wet soil. Widespread throughout the state. (Philson, Leatherwood, and Whitford). WFC #144. Common from early spring to fall.

Hydrocoleum comoides Gom.
"Forming dark-gray patches on rocks about 2 ft. above mean low tide level.

Cape Lookout now becomes the northern limit of its distribution on the east coast of the United States" (Williams). Summer.

**H. homoeotrichum* Kuetzing.
Growing on damp soil in a corn field. Rowan Co. WFC #210. July.

Schizothrix aikenensis (Wolle) Philson.
Mud, decaying vegetable matter in pool. Durham Co. (Philson), Anson Co. WFC #256. July.

**S. arenaria* (Berk.) Gomont.
Clay bank on road east of Highlands Museum. Macon Co. WFC #296. August.

S. Friesii (Agardh) Gomont.
On damp soil and rocks. Durham Co. (Philson), Randolph Co. WFC #253. July.

**S. hyalina* Kuetzing.
On mud along Caraway Creek. Randolph Co. WFC #254. July.

**S. Lamyi* Gomont.
Mountains of N. C. (Bold, CM, UT).

**S. lardacea* (Cesati) Gomont.
Mountains of N. C. (Bold, CM, UT).

**S. Muelleri* Naegeli.
Wet rocks. Mountains of North Carolina (Bold #401), Jackson Co. WFC #270. August.

**S. purpurascens* (Kuetz.) Gomont.
Common on damp soil. Wake, Moore, Nash, Macon, Cabarrus Cos. WFC #213, 275. Summer.

**S. symplocoides* (Gard.) Geitler.
Moist banks. Nash and Macon Cos. WFC #225. Summer.
Forming patches on moist soil along stream. Johnston Co. WFC #160. June.

**S. telephoroides* (Mont.) Gomont.
Moist banks of streams. Johnston Co. WFC #160. June.

**Hypheothrix herbacea* Kuetzing.
Abundant on flower pots in greenhouse. Edgecombe Co. WFC #167. June.

Suborder 2 HETEROCYSTINEAE

Family 1 *Nostocaceae*

Anabaena affinis Lemmermann.
In plankton of ponds. Wayne, Wake Cos. (Whitford), Edgecombe Co. Summer.

A. Azollae Strasburger.
Apparently throughout the Coastal Plain in leaves of *Azolla caroliniana* (Whitford).

**A. confervoides* Reinsch.
On freshwater algae. WFC #264. August.

A. circinalis (Kuetz.) Hansgirg.
"Rare in the plankton of a pool near Princeton, Wayne Co." (Whitford), Bertie Co. WFC #145.
A. Cycadeae J. Reinke.
On roots of a cycad, *Zamia floridana*. Durham Co. (Philson).
A. flos-aquae (Lyng.) Brébisson.
With other algae in small stream in Duke Forest. Durham Co. (Philson).
**A. inaequalis* (Kuetz.) Bornet and Flahault.
In plankton. Wake, Edgecombe, Nash, Martin, Greene, Pitt, Chowan, Johnston, Person Cos. WFC #103. June.
A. laxa (Rabenh.) A. Braun.
On mud in roadside drain. McDowell Co. (Philson), Anson Co. WFC #258. July.
A. oscillarioides Bory.
Forming gelatinous masses in shallow pools. Wake Co. (Whitford), Duplin Co. WFC #230. Summer.
**A. sphaerica* Bornet and Flahault.
Along the edge of Lake Ravenel, Highlands. Macon Co. WFC #299. August.
A. torulosa (Carm.) Lagerheim.
Occurring in plankton. Durham Co. (Philson), Edgecombe Co. WFC #151. June.
**A. variabilis* Kuetzing.
On moist garden soil. WFC #231. July.
**Nostoc comminutum* Kuetzing.
On submerged wood. Pitt and Chowan Cos. WFC #132. June.
N. commune Vaucher.
Widespread on wet soil and seepages. Forsyth Co. (von Schweinitz, described by Drouet). Abundant in Piedmont (Whitford, Curtis). WFC #100. Most abundant in spring and autumn.
N. microscopicum Carmichael.
Common on wet rocks and moist soils. Swain Co. (Whitford), Macon, Jackson, Graham, Orange, and Wake Cos. WFC #193. Summer.
N. muscorum Agardh.
On wet soil. Wake Co. (Leatherwood), Camden, Johnston, Guilford Cos. WFC #147. June.
N. paludosum Kuetzing.
On flooded soil. Durham Co. (Philson), Wake Co. (Leatherwood).
N. parmelioides Kuetzing.
Pools and streams. Wake and Carteret Cos. (Whitford). Spring.
N. peltigerae Letellier.
"The algal symbiont in a lichen common on wet soil." Wake Co. (Whitford). All seasons.
**N. piscinale* Kuetzing.

This is Drouet's annotation on Philson's 1939 herbarium specimen which represented the type of *Anabaena parva* Philson. Wake Co. (Leatherwood). March.

N. punctiforme (Kuetz.) Hariot.

"Forming, with other unicellular species of blue-green algae, a thin coating on submerged rock in a nearby stream." Durham Co. (Philson), Wake, Person, Vance, and Warren Cos. July.

N. sphaericum Vaucher.

On submerged wood. Polk Co. (Green, 1897), Wake Co. (Leatherwood). Spring.

Aphanizomenon flos-aquae (Linn.) Ralfs.

"Occasional in plankton of Coastal Plain ponds" (Whitford); Wilson Co. Summer.

Cylindrospermum alatosporum F. E. Fritsch.

Growing with *Vaucheria*. Durham Co. (Philson).

C. catenatum Ralfs.

On submerged wood. Haywood Co. (Leatherwood), Johnston, Camden, Edgecombe, New Hanover, Duplin, Cleveland Cos. WFC #136. Summer.

**C. comatum* Wood.

On damp soil in greenhouse. Orange Co. WFC #192. July.

**C. licheniforme* (Bory) Kuetzing.

Mountains of N. C. (Bold #380, CM, UT).

**C. majus* Keutzing.

On mud in roadside drain. Mountains of N. C. (Bold #380). WFC #257. July.

**C. minutissimum* Collins.

Muddy banks of Pee Dee River. Montgomery Co. WFC #263. July.

C. minutum Wood.

On *Anthoceros*. Wake Co. (Leatherwood), Caswell Co. WFC #252. June.

C. muscicola Kuetzing.

Along muddy banks. Wake Co. (Leatherwood), Durham Co. (Philson), Alamance Co. WFC #184. Summer.

C. stagnale (Kuetz.) Bornet and Flahault. Mud, damp earth, flower pots. Haywood Co. (Leatherwood), Jackson, Macon, Transylvania, Johnston, and Wake Cos. WFC #162, 293. Summer.

C. trichotospermum Frémy.

Plant masses on mud shaded by large trees. Durham and McDowell Cos. (Philson).

Nodularia Harveyana (Thwaites) Thuret.

In small pools. New Hanover Co. (Whitford), Duplin Co. March, July.

N. spumigena Mertens.

Stagnant pools. Craven Co. (Whitford), Macon Co.

Family 2 *Scytonemataceae*

**Scytonema Arcangelii* Bornet and Flahault.
Attached to rocks and submerged wood. Wake and Wilson Cos. WFC #228.

**S. Austinii* Wood.
On submerged stump in Lake Ravenel, Highlands. Macon Co. Summer.

S. Battersii Gomont.
Wet soil on Ocracoke Island. Dare Co. (Hoyt). August 1918.

S. carolinianum Philson.
Damp rich soil on decaying vegetable matter, decaying grass in road drain. Durham Co. (Philson), Nash Co.

**S. crassum* Naegeli.
Mountains of North Carolina (Bold #302, CM).

S. dubium Wood.
Submerged wood. Macon Co. Summer.

S. figuratum Agardh.
Moist earth and rocks. Warren Springs (Smith, 1880); Buncombe Co. (von Schweinitz 1812, reported by Drouet), Wake Co. (Leatherwood, Whitford).

S. guyanense (Mont.) Bornet and Flahault.
Wet ground and tree trunks. Forsyth Co. (von Schweinitz, 1812, reported by Drouet)

S. Hofmanni Agardh.
Wet wood, rocks and soil. Widespread over the state. (Leatherwood). All seasons.

S. insigne W. and G. S. West.
"Growing in patches on wet soil and limestone rocks." Durham Co. (Philson).

**S. javanicum* (Kuetz.) Bornet.
Moist wood and on base of tree trunks. Warren and Bertie Cos. WFC #178, 129. June.

**S. Millei* Bornet.
On wet rocks and moist soil. Wake and Caswell Cos. WFC #186. Summer.

S. mirabile (Dill.) Bornet.
On moist earth and rocks in streams. Wake Co. (Leatherwood), Pender Co. WFC #253. March–June.

S. myochrous (Dill.) Agardh.
On wet exposed rocks. Reported by Ravenel in 1877. Macon Co. WFC #287. August.

**S. ocellatum* Lyngbye.
With moss at base of tree trunks at water level. Wilson Co. WFC #226. Mountains of N. C. (Bold #374). Summer.

*S. *siculum* Borzi.
On sand and rocks along beach. Dare Co. WFC #153. June.
*S. *varium* Kuetzing.
On submerged wood Lake Asheboro. Randolph Co. WFC #261. July.
*S. *stuposum* (Kuetz.) Bornet.
Forming a brown covering on rocks exposed in river. Johnston Co. WFC #158. Mountains of N. C. (Bold #269).
*S. *tolypotrichoides* Kuetzing.
On submerged boards. Onslow Co. WFC #251. Mountains of N. C. (Bold #147). Summer.
**Plectonema Boryanum* Gomont.
Submerged wood in Wilmington City Park. New Hanover Co. July.
*P. *gracillimum* (Zopf) Hansgirg.
Attached to submerged rocks. Macon Co. WFC #267. August.
*P. *nostocorum* Bornet.
Seeping rocks. Macon Co. WFC #280. August.
*P. *phormidioides* Hansgirg.
On wet rocks with other algae. Dare Co. WFC #152. June.
*P. *Tomasiniana* Bornet.
On rocks along edge of Pasquotank River. Pasquotank Co. WFC #155. June.
**Tolypothrix Bouteillei* (Bréb. and Desm.) Lemmermann.
On inner surface of wooden trough just above water level. Rockingham Co.
*T. *fragilis* (Gard.) Geitler.
On decaying wood. Warren Co. June.
T. *lanata* (Desv.) Wartmann.
Shallow pools. Wake Co. (Leatherwood). Widespread in Piedmont and Coastal Plain. Summer.
*T. *limbata* Thuret.
On submerged brick. Lee Co. July.
*T. *papyracea* Gardner.
On rocks over which water was trickling. Jackson Co. August.
T. *penicillata* (Agardh) Thuret.
On moist rocks. Wake Co. (Leatherwood). Spring.
T. *Rechingeri* (Wille) Geitler.
"Growing in a loose mass on trunk of a cedar tree near Duke University." Durham Co. (Philson).
*T. *rupestris* Wolle.
On wet rocks at waterfalls. Clay Co. August.
*T. *tenuis* Kuetzing.
Attached to wet rocks and submerged boards. Wake Co. (Leatherwood). Apparently occurring throughout the state. Summer.
**Hassalia byssoidea* (Berk.) Hassall.
Mountains of N. C. (Bold).

**Diplocolon Heppii* Naegeli.
On submerged sticks. Onslow Co. WFC #251. July.
**Desmonema Wrangelii* (Agardh) Bornet and Flahault.
On concrete footings in a swift stream. Warren Co. WFC #116. June.
**Microchaete tenera* Thuret.
On wet boards under spillway. Guilford Co. WFC #101. July.
**M. tenuissima* W. and G. S. West.
Attached to the edge of a wooden trough. Craven Co. WFC #185. June.
**Fremyella striatula* (Hy) Drouet.
Mountains of N. C. (Bold #168). Summer.

Family 3 *Stigonemataceae*

Stigonema hormoides (Kuetz.) Bornet and Flahault.
On wet rocks and attached to aquatics. Durham Co. (Philson), Wake Co. (Whitford), Bladen, Wilson, and Macon Cos. WFC #123. All seasons.
S. informe Kuetzing.
Moist and dripping rocks. Durham Co. (Philson), Macon, Wake, and Henderson Cos. WFC #280. Summer.
S. mamillosum (Lyng.) Agardh.
Wet rocks and submerged wood. Wake Co. (Whitford), Wilson, Sampson, Robeson Cos. WFC #229. Summer.
**S. mesentericum* Geitler.
Dripping rocks. Macon Co. WFC #280. Summer.
S. minutum (Agardh) Hassall.
Common on wet soil. Wake Co. (Whitford), Nash Co. WFC #225. All seasons.
S. minutum var. *saxicola* (Naeg.) Bornet and Flahault. On wet rocks. Wake Co. (Leatherwood). March.
**S. mirabile* Beck v. Mannag.
On wet rocks. Macon Co. WFC #284.
S. panniforme Bornet and Flahault.
Dry exposed rocks. Durham Co. (Philson), Macon Co. WFC #295. August.
S. turfaceum Cooke.
Moist earth and rocks. Durham Co. (Philson), Nash, Macon, Cherokee Cos. WFC #266. Summer.
**S. tomentosum* (Kuetz.) Hieronymus.
Exposed rocks. Jackson, Clay, and Macon Cos. WFC #298, 269. August.
Fischerella ambigua (Naeg.) Gomont.
In pools and on submerged rocks and wood. Johnston, Cumberland, Swain Cos. Mountains of N. C. (Bold). WFC #234. Summer.
**F. Letestui* Frémy.
On partially submerged wood. Wayne and Johnston Cos. WFC #161. July.

F. maior Gomont.
On submerged stems and leaves. Pender Co. (Whitford), Wilson Co. WFC #237. July.

**F. muscicola* (Thuret) Gomont.
On moist clay. Wake Co.

**F. thermalis* (Bornet and Flah.) Gomont.
Mountains of North Carolina (Bold #224, CM, UT).

**Hapalosiphon arboreus* West and West.
With moss and other algae on a wet clay bank. Wake Co. WFC #249. Spring and summer.

H. aureus West and West.
Submerged log, moist earth in drain canal. Wake Co. (Leatherwood), Craven Co. July.

**H. flexosus* Borzi.
On submerged roots in White Lake. Bladen Co. WFC #224. July.

H. fontinalis (Agardh) Bornet.
On submerged wood or aquatics. Bladen, Craven, and Wake Cos. (Whitford), Haywood Co. (Leatherwood). WFC #248. Common at all seasons.

H. hibernicus W. and G. S. West.
Growing on submerged wood and vegetation. Wake and Craven Cos. (Whitford), Moore Co. WFC #259. July.

**H. intricatus* West and West.
On wood beams under dam at golf course pond, Highlands. Macon Co. WFC #292. August.

H. Welwitschii W. and G. S. West.
On moist soil. Durham Co. (Philson).

Family 4 *Rivulariaceae*

**Amphithrix janthina* (Mont.) Bornet and Flahault.
On wet concrete under mill near Wilson. Wilson Co. Mountains of N. C. (Bold). WFC #216. July.

**Calothrix adscendens* (Naeg.) Bornet and Flahault.
With other algae in water fountain in Wilmington. New Hanover Co. WFC #245. July.

C. Braunii Bornet and Flahault.
On wet boards, rocks, and dams. Durham Co. (Philson), Haywood Co. (Leatherwood), Wake, Franklin, Sampson, Macon, Jackson, Lincoln, Edgecombe, Nash, Hyde, and Vance Cos. WFC #101. Summer.

C. confervicola C. Agardh.
Epiphytic on sea weeds. Piver's Island (Blomquist); Dare Co. WFC #168. June.

C. crustacea Thuret *in* Bornet and Flahault.
On oyster and clam shells along the beach, Piver's Island (Blomquist, Williams); Atlantica, Carteret Co. June and July.

**C. donelli* (Wolle) De Toni.
Attached to submerged wood. Chowan Co. WFC #132. June.

*C. *Elenkinii* Kossinskaja.
On submerged rocks at drinking fountain, Mr. Morrow. Stanly Co. WFC #251. July.

*C. *epiphytica* West and West.
On green algae. Camden Co. WFC #137. June.

C. *fusca* (Kuetz.) Bornet and Flahault.
Mixed with other algae. Wake Co. (Leatherwood), Edgecombe, Bertie, Camden Cos. WFC #124. June.

C. *juliana* (Menegh.) Bornet and Flahault.
On concrete dam. Haywood Co. (Leatherwood). August.

*C. *parietina* (Naeg.) Thuret.
On moist rocks and in water fountain. Jackson, Nash, New Hanover, and Rutherford Cos. WFC #187. Summer.

*C. *prolifera* Flahault.
Submerged wood in salt water. Dare Co. WFC #154. June.

*C. *pulvinata* Kuetzing.
On stump exposed at low tide, Nag's Head. Dare Co. WFC #148. June.

C. *scopularum* C. Agardh *ex* Bornet and Flahault.
On buoy mixed with other algae. Cape Lookout Shoal Station Buoy No. 14 (Humm); along the coast (Williams). Summer.

C. *scytonemicola* Tilden.
Ponds. Wake Co. (Leatherwood). Spring.

*C. *simulans* Gardner.
Lake Ravenel, Highlands. Macon Co. WFC #309. August.

*C. *stellaris* Bornet and Flahault.
Mountains of N. C. (Bold #173, CM, UT).

**Dichothrix Baueriana* (Grunow) Bornet and Flahault.
On dripping rocks with other algae. Macon Co. WFC #289. August. Mountains of N. C. (Bold #173, CM, UT).

*D. *compacta* (Agardh) Bornet and Flahault.
On submerged stump in White Lake. Bladen Co. WFC #223. July.

D. *fucicola* (Kuetz.) Bornet and Flahault.
Epiphytic on *Sargassum natans*. Harker's Island, Carteret Co. (Blomquist).

*D. *gypsophila* (Kuetz.) Bornet and Flahault.
On dripping rocks. Jackson Co. WFC #274. August.

*D. *Meneghiniana* (Kuetz.) Forti.
On submerged wood. Cumberland Co. WFC #236. July.

*D. *orsiniana* (Kuetz.) Bornet and Flahault.
On submerged rocks and boards. Pasquotank and Jackson Cos. WFC #139. Summer.

*D. *spiralis* Fritsch.
A few filaments collected in a shallow rock pool at Mitchell's Mill. Wake Co. WFC #103. June.

***Rivularia Beccariana* (deNot.) Bornet and Flahault. Mountains of N. C. (Bold #165, UT).

Gloeotrichia echinulata (J. E. Smith) P. Richter.
On submerged aquatics or floating. Wake and Wilson Cos. (Whitford), Guilford Co. WFC #172. Summer.

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ADDITIONS TO THE ALGAE OF THE SOUTHEASTERN UNITED STATES

By Herman Silva

Department of Botany and Plant Pathology, Michigan State College
East Lansing, Michigan

Until the last two decades there have been but few investigators of the algae among resident botanists of the southeastern United States, and there are still few research facilities for the pursuit of phycological studies in the region, such as herbaria and libraries. During the past twenty years, however, interest in the algae has gained momentum because of the establishment there of a small group of trained investigators who have a special interest in local algal flora.

Whereas development of recreational fishing in the Mid-west stimulated special, intensive phycological work, the studies in the Southeast have remained almost exclusively general, and for the most part systematic. Among the studies, however, have been two special investigations on soil algae which open the door on what should be a most productive field. A résumé of the more significant of the published studies, and a southeastern bibliography of sixty-one titles can be found in Silva (1948).

During the writer's studies extending over the past six years, it has become apparent that an over-all picture of the algal flora of the region would be valuable. In order to relate the many individual reports, some of which are very limited in scope, a catalogue has been prepared in which the algae known for the ten southeastern states are listed. This compilation will be published soon as a contribution toward a general conspectus.

At present, publication of algal studies has lagged rather far behind collection and identification so that valuable records are not generally available. It is the purpose of the present paper to make known some of these records, whereas the catalogue will include all known published reports.

There has been such an accumulation of information that the publication of all of it does not seem practicable and the following course has been adopted:

1. The forthcoming catalogue will include previously published references only, the dates and authors of publications applying to the species being systematically assembled.

2. Original collection data, which have not been published previously, appear here. States are used as the unit area of reporting.

3. The writer's identification of species already reported from a state are not mentioned.

4. When two or more identified collections of a single species were found from a particular state, only one is mentioned.

5. Exceptions to these rules are usually noted in the text.

6. The Çyanophyta are not included herein.

Much of the credit for this paper is due to Dr. H. C. Bold who has provided the

substantial set of specimens and records assembled with the aid of his students in four states, Dr. G. W. Prescott for the opportunity to examine his Florida collections and for his valuable guidance, and to Mr. Hugh H. Iltis and Mr. Albert Clebsch for their cooperation.

The following abbreviations will be found in the text:

B—H. C. Bold
GP—G. W. Prescott
H—H. C. Bold
S—Herman Silva

Phylum CHRYSOPHYTA

Class **Heterokontae**

Order HETEROCOCCALES

Family *Ophiocytiaceae*

Ophiocytium Naegeli 1849

1. *Ophiocytium cochleare* A. Braun—TENN., among filamentous algae in pool near Glen Echo Lake, Davidson Co. Feb. 19, 1939, B-3936.

Order HETEROTRICHALES

Family *Tribonemataceae*

Tribonema Derbes & Solier 1856

1. *Tribonema minus* (Wille) Hazen—S. C., branch in field near Walhalla, Oconee Co. May 21, 1939; FLA., on submerged vegetation in Ashby Lake, Volusia Co. June 15, 1941, GP-1.
2. *T. utriculosa* (Kuetz.) Hazen—N. C., on grass in spring branch and swamp in running water near Pearson's Lake, Polk Co., with *Draparnaldia* sp. May 5, 1939, H-16.

Order HETEROSIPHONALES

Family *Botrydiaceae*

Botrydium Wallroth 1815

1. *Botrydium granulatum* (L.) Grev.—TENN., moist soil, Orphans' Home, Spring Hill, Maury Co. Sept. 24, 1938, B-132.

Class **Chrysophyceae**

Order CHRYSOMONADALES

Family *Chromulinaceae*

Chrysopyxis Stein 1878

1. *Chrysopyxis* sp.—S. C., on *Mougeotia* sp. in swamp near Cedar Mt. Greenville Co. Aug. 10, 1939, H-432.

Family *Ochromonadaceae*

Dinobryon Ehrenberg 1835

1. *Dinobryon divergens* (Stokes) Lemm.—TENN., Chilowee Park Lake at Knoxville, Knox Co. June 29, 1938, Bold.
2. *D. sertularia* Ehr.—TENN., Chilowee Park Lake at Knoxville, Knox Co. July 15, 1938, Bold.

Uroglenopsis Lemmerman 1899

1. *Uroglenopsis americana* (Calkins) Lemm.—N. C., Phillips Lake, 18°C. Macon Co. May 15, 1939, H-26.

Phylum CHLOROPHYTA

Class **Chlorophyceae**

Order VOLVOCALES

Family *Chlamydomonadaceae*

Carteria Diezing 1886

1. *Carteria Fritschii* Takeda—N. C., Phillips Lake, temp. 18°C, Macon Co. May 11, 1939, H-42b.

Chlamydomonas Ehrenberg 1833

1. *Chlamydomonas clathrata* (Korsh.) Pascher—N. C., pool on Yellow Mountain, elv. 5000 ft., Jackson Co. June 11, 1939, H-122. (There was another collection from the same site made three days later.)
2. *C. conversa* Korsh.—GA., pool off inlet to Chattooga River, Rabun Co. May 22, 1939, H-58.
3. *C. Ehrenbergii* Gorosh.—TENN., pool beside road near Strawberry Plains, Knox Co. June 30, 1938, B-24e.
4. *C. gloeogama* Korsh.—N. C., pasture pools near Phillips Lake, with *Carteria Fritschii* Takeda, Macon Co. May 15, 1939; S. C., pool near water trough near Walhalla, Oconee Co. May 21, 1939, H-56.
5. *C. nasuta* Korsh.—N. C., fish-rearing pools at Wolf Mt. Lumber Co. Club, Jackson Co. June 15, 1939, H-147.
6. *C. pseudopertyi* Pascher—TENN., swampy pool beside road near Strawberry Plains, Knox Co. June 30, 1938, B-24.

Chlorogonium Ehrenberg 1830

1. *Chlorogonium tetragamum* Bohlin—TENN., roadside ditch near Greenbrier Cove, Sevier Co. July 16, 1939, H-331.

Family *Phacotaceae*

Phacotus Perty 1852

1. *Phaçotus angustus* Pascher—TENN., pool in brook near Laura Lake, Maury Co. Sept. 24, 1939, B-112.

2. *P. lenticularis* (Ehr.) Stein—TENN., plankton from Norris Lake, Campbell Co. June 21, 1938, Bold. (The species was previously reported from the state by Lackey, 1942.)

Family *Volvocaceae*

Pleodorina Shaw 1894

1. *Pleodorina californica* Shaw—TENN., permanent pond north of Tazewell, Claiborne Co. June 26, 1939, Bold.

Volvox Linnaeus 1758

1. *Volvox perglobator* Powers—TENN., permanent pond north of Tazewell, Claiborne Co. June 26, 1938, Bold.

Order TETRASPORALES

Family *Sphaerellaceae*

Sphaerella Sommerfelt 1824

1. *Sphaerella lacustris* (Girod) Wittr.—FLA., on submerged vegetation of Ashby Lake, Volusia Co. June 15, 1941, GP-1; TENN., bird bath at Beverly, Knox Co. July 7, 1938, Bold.

Stephanosphaera Cohn 1858

1. *Stephanosphaera pluviatilis* Cohn—N. C., rock pools on summit of Whiteside Mt., elv. 4900 ft., Jackson Co. June 4, 1939, H-95. (The only other report for southeastern United States was made from the same state by Whitford, 1943.)

Family *Palmellaceae*

Asterococcus Scherffel 1908

1. *Asterococcus limneticus* G. M. Smith– FLA., small pond near Florida highway 28 not far from Flagler Beach, Flagler Co. June 16, 1941; TENN., fish pool at Ijams' place, Knox Co. July 11, 1938, Bold.
2. *A. superbus* (Cienk.) Scherffel—N. C., Lake Sequoyah, Macon Co. May 23, 1939, Bold.

Gloeocystis Naegeli 1849

1. *Gloeocystis ampla* (Kuetz.) Lagerh.—TENN., permanent pond north of Tazewell, Claiborne Co. June 26, 1938, Bold, and on *Sphagnum* sp. at Ramsey Cascade, elv. 4150 ft., Sevier Co. July 18, 1939, Bold.
2. *G. confluens* (Kuetz.) P. Richt.—TENN., wet rocks beside trail near Newfound Gap, elv. 5500 ft., Sevier Co. S-610. (The writer has made other collections from similar habitats in the vicinity.)

Sphaerocystis Chodat 1897

1. *Sphaerocystis Schroeteri* Chod.—TENN., plankton from Norris Lake, Campbell Co. June 26, 1938, Bold.

Urococcus Kuetzing 1849

1. *Urococcus Hookerianus* Berk. & Hassall—TENN., limestone pools of small pool entering lake below high water mark of Norris Lake in Cove Creek inlet, Campbell Co. April 12, 1947, S-632.

Family *Tetrasporaceae*

Apiocystis Naegeli 1849

1. *Apiocystis Brauniana* Naeg.—S. C., on a cliff by Eastatoe River, Oconee Co. July 2, 1939, H-259a.

Schizochlamys A. Braun 1849

1. *Schizochlamys gelatinosa* A. Braun—N. C., in frog pond four miles west of Franklin, Macon Co. July 11, 1939, H-316.

Tetraspora Link 1809

1. *Tetraspora cylindrica* (Wahlb.) Agardh—TENN., attached to rocks in quiet river pool in Ramsey Prong, elv. 3250 ft., Sevier Co. Sept. 5, 1941, S-188.
2. *T. gelatinosa* (Vaucher) Desv.—N. C., roadside rocks, Jackson Co. June 6, 1939, H-110; TENN., Chilowee Park Lake at Knoxville, Knox Co. June 29, 1938, Bold.

Family *Coccomyxaceae*

Coccomyxa Schmidle 1901

1. *Coccomyxa dispar* Schm.—N. C., on partly submerged burned log in Phillips Lake, Macon Co. May 15, 1938, H-52.

Nannochloris Naumann 1919

1. *Nannochloris bacillaris* Naumann—TENN., bird bath at Beverly, Knox Co. June 19, 1938, Bold. (The species was also collected in a culture of fern prothallia at the University of Tennessee at Knoxville.)

Order ULOTRICHALES

Family *Ulotrichaceae*

Binuclearia Wittrock 1886

1. *Binuclearia tatrana* Wittr.—N. C., on aquatic angiosperms in Lake Sequoyah, Macon Co. May 22, 1939, H-72, and another collection from John Wesley Edwards Lake in Jackson Co. on June 20, 1939. (The only other report from southeastern United States was from the same state by Whitford, 1943.)

Stichococcus Naegeli 1849 emend. Gay 1891

1. *Stichococcus flaccidus* (Kuetz.) Gay—TENN., dried up puddle on bare soil of field at Booth Kennels, Knox Co. Mar. 18, 1947, S-519.
2. *S. fluitans* Gay—TENN., on mosses at Ramsey Cascade, elv. 4150 ft., Sevier Co. July 18, 1939, H-346.
3. *S. rivularis* (Kuetz.) Hazen—TENN., on wet rock ledge beside Ramsey Cascade, elv. 4200 ft., Dec. 28, 1946, H-417.

Ulothrix Kuetzing 1833

1. *Ulothrix aequalis* Kuetz.—TENN., on stones in brook near highway U. S. 70 at Kingston Springs, Davidson Co. Mar. 5, 1939, B-3947.
2. *U. tenuissima* Kuetz.—N. C., pools on Yellow Mt., elv. 5100 ft., Jackson Co. June 14, 1939, H-139; TENN., on stones in brook near highway U. S. 70 at Kingston Springs, Davidson Co. Mar. 5, 1939, B-3947.
3. *U. variabilis* Kuetz.—N. C., spring log at Moore's Cabin Spring on Gregory Bald, Graham Co. Jan. 26, 1942, S-202.

Order MICROSPORALES

Family *Microsporaceae*

Microspora Thuret 1850 emend. Lagerheim 1888

1. *Microspora amoena* (Kuetz.) Lagerh.—N. C., shallow water on south shore of Lake Sequoyah, Macon Co. May 22, 1939, H-60; TENN., on vegetable matter in roadside puddle southeast of Knoxville, elv. 1000 ft., Knox Co. Mar. 19, 1947, S-532.
2. *M. stagnorum* (Kuetz.) Lagerh.—S. C., Brown's Lake, pH 6.6, Mt. Rest, Oconee Co. June 12, 1939, H-123.
3. *M. Wittrockii* Lagerh.—GA., pool off outlet to Chattooga River, Rabun Co. May 22, 1939, H-59.

Order CYLINDROCAPSALES

Family *Cylindrocapsaceae*

Cylindrocapsa Reinsch 1867

1. *Cylindrocapsa geminella* Wolle—TENN., on *Cladophora* sp. in Hidden Lake, Davidson Co. Sept. 17, 1938, B-104a.

Order CHAETOPHORALES

Family *Chaetophoraceae*

Chaetophora Schrank 1789

1. *Chaetophora elegans* (Roth) Agardh—N. C., Ravenel Lake, Macon Co. May 13, 1939, H-36; TENN., globular jelly masses among weeds in water at Carter's Mill, Knox Co. April 2, 1947, S-560.

2. *C. incrassata* (Hudson) Hazen—TENN., Cunningham Lake, fed with small stream, near Clarksville, Montgomery Co. April 30, 1948, Alfred Clebsch-7.

Chlorotylium Kuetzing 1843

1. *Chlorotylium cataractarum* Kuetz.—TENN., in limestone pools below high water line at entrance of small stream to Cove Creek inlet of Norris Lake, Campbell Co. April 12, 1947, S-632.

Draparnaldia Bory 1808

1. *Draparnaldia acuta* (Agardh) Kuetz.—TENN., in clear, cold, moderately fast spring run-off in Fountain City Park, Knox Co. May 23, 1946.
2. *D. platyzonata* Hazen—TENN., on large rocks in Ramsey Prong, elv. 1600 ft., Sevier Co. Nov. 24, 1946, S-368.
3. *D. pulmosa* (Vaucher) Agardh—TENN., clear soil-bottomed pool of stream below Newfound Gap Highway, elv. 1700 ft., Sevier Co. April 20, 1947, S-607.

Microthamnion Naegeli 1849

1. *Microthamnion Kuetzingianum* Naeg.—TENN., clinging to rocks and humus in Porter's Prong, elv. 3500 ft., Sept. 6, 1941, Sevier Co. S-159.

Stigeoclonium Kuetzing 1843

1. *Stigeoclonium aestivale* (Hazen) Coll.—N. C., Kalalanta Swamp, Transylvania Co. June 5, 1939, H-102.
2. *S. attenuatum* (Hazen) Coll.—TENN., on propeller of ferryboat on river at Sweetwater, Monroe Co. July 7, 1938, Bold.
3. *S. lubricum* (Dillw.) Kuetz.—TENN., in roadside drain pH 4.5–5.0 beside Roaring Fork Road one half mile from Gatlinburg, Sevier Co. Nov. 24, 1946, S-348.
4. *S. nanum* (Dillw.) Kuetz.—FLA., plankton sample from Ashby Lake, Volusia Co. June 16, 1941, GP-2.
5. *S. tenue* (Agardh) Kuetz.—TENN., on submerged rocks in stream by Grassy Patch parking area, Sevier Co. Aug. 12, 1941, S-39.
6. *S. thermale* A. Braun—S. C., on board in still water, no date given, Rav-263.

Family *Protococcaceae*

Protococcus Agardh 1824

1. *Protococcus viridis* Agardh—TENN., on bark of tree near Avondale Springs, Grainger Co. May 5, 1947, S-591. (This species is so very common that few bother to report it, even for the sake of record.)

Family *Coleochaetaceae*

Chaetosphaeridium Klebahn 1892

1. *Chaetosphaeridium Pringsheimii* Klebahn—N. C., High Hampton Lake, pH 7.2, Jackson Co. June 2, 1939, H-87.

Coleochaete de Brébisson 1844

1. *Coleochaete irregularis* Prings.—TENN., permanent pond north of Tazewell, Claiborne Co. June 26, 1938, Bold.
2. *C. nitellarum* Jost—N. C., on *Nitella* sp. in High Hampton Lake, Jackson Co. July 12, 1939, H-326.
3. *C. orbicularis* Prings.—TENN., permanent pond north of Tazewell, Claiborne Co. June 26, 1938, Bold.
4. *C. pulvinata* A. Braun—S. C., plankton from Brown's Lake, pH 6.6, Oconee Co. June 12, 1939, H-123.
5. *C. scutata* (Bréb.) Prings.—N. C., Haywood Co. July 7, 1939, H-362a.

Family *Trentepohliaceae*

Trentepohlia Martius 1817

1. *Trentepohlia aurea* (L) Martius—N. C., rocks in lower Cullasaja Gorge, Macon Co. June 24, 1939, H-199.

Order SCHIZOGONIALES

Family *Schizogoniaceae*

Schizogonium Kuetzing 1843

1. *Schizogonium murale* Kuetz.—TENN., wet trailside rock 7.9 miles east of Newfound Gap, elv. 5500 ft., Sevier Co. Sept. 4, 1941, S-117.

Order CHLOROCOCCALES

Family *Endosphaeraceae*

Kentrosphaeria Borzi 1883

1. *Kentrosphaeria* sp.—N. C., rock pools at summit of Yellow Mountain, Jackson Co. June 14, 1939, B-141.

Family *Characiaceae*

Characium A. Braun 1849

1. *Characium Debaryanum* (Reinsch) DeToni—TENN., roadside pool, Jefferson Co. June 26, 1938, Bold.

Family *Protosiphonaceae*

Protosiphon Klebs 1896

1. *Protosiphon botryoides* (Kuetz.) Klebs—TENN., on a stick in mixed stream and backwater of Ft. Loudon Lake (Tennessee River) below Knoxville, Knox Co. April 5, 1947, S-584.

Family *Hydrodictyaceae*

Hydrodictyon Roth 1800

1. *Hydrodictyon reticulatum* (L) Lagerh.—TENN., spring-fed lake at Orphans' Home, Spring Hill, Maury Co. Sept. 24, 1938, B-117b.

Family *Coelastraceae*

Coelastrum Naegeli 1849

1. *Coelastrum proboscideum* Bohlin—N. C., Fairfield Lake, Jackson Co. August 4, 139, H-415.

Family *Oocystaceae*

Ankistrodesmus Corda 1838 emend. Ralfs 1848

1. *Ankistrodesmus falcatus* (Corda) Ralfs—FLA., on submerged vegetation in Ashby Lake, Volusia Co. June 15, 1941, GP-1.
2. *A. spiralis* (Turner) Lemm.—TENN., fish-rearing pools below Norris Dam, Anderson Co. June 26, 1938, Bold.

Chlorella Beyerinck 1890

1. *Chlorella conductrix* Brandt—FLA., in pond near Osteen, Volusia Co. June 15, 1941, GP-6.

Dimorphococcus A. Braun 1855

1. *Dimorphococcus lunatus* A. Braun—TENN., in lily pool on campus of Vanderbilt University, Nashville, Davidson Co. Nov. 12, 1938, B-154a.

Eremosphaera De Bary 1858

1. *Eremosphaera viridis* De Bary—S. C., plankton from Brown's Lake, Mt. Rest, Oconee Co. May 21, 1939, H-69, and the same site on June 12, 1939; FLA., on submerged vegetation in Ashby Lake, Volusia Co. June 15, 1941, GP-1.

Kirchneriella Schmidle 1893

1. *Kirchneriella lunaris* (Kirch.) Moebius—GA., cliff pool near Clayton, Rabun Co. July 5, 1939, H-288.

Nephrocytium Naegeli 1849

1. *Nephrocytium Agardhianum* Naeg.—TENN., permanent pond north of Tazewell, Claiborne Co. June 26, 1938, Bold.

Oocystis Naegeli 1845

1. *Oocystis Borgei* Snow—FLA., on vegetation in pond near Osteen, Volusia Co., Jan. 15, 1941, GP-1.
2. *O. elliptica* W. West—N. C., gelatinous coating on wet rock at Bridal Veil Falls, Macon Co. May 14, 1939, H-41a.
3. *O. lacustris* Chod.—FLA., in small pond near Florida state highway 28 near Flagler Beach, Flagler Co. June 16, 1941, GP-10.
4. *O. rupestris* Kirch.—TENN., in rock pools at Ramsey Cascade, elv. 4150 ft., Sevier Co. July 18, 1939.

Selenastrum Reinsch 1867

1. *Selenastrum minutum* (Naeg.) Coll.—TENN., in fish pool on Sanford Estate, Knoxville, Knox Co. July 7, 1938, Bold.

Family *Scenedesmaceae*

Scenedesmus Meyen 1829

1. *S. longus* var. *ellipticus* (West & West) G. M. Smith—FLA., on submerged aquatics and on ground at edge of small lake near Osteen, Volusia Co. June 15, 1941, GP-9.
2. *S. quadricauda* var. *dispar* Bréb.—FLA., on vegetation in pond near Osteen, Volusia Co. June 15, 1941, GP-6.
3. *S. quadricauda* var. *quadrispina* (Chodat) G. M. Smith—FLA., on submerged vegetation in Ashby Lake, Volusia Co. June 15, 1941, GP-1.

Family *Botryococcaceae*

Botryococcus Kuetzing 1849

1. *Botryococcus Braunii* Kuetz.—TENN., fish-rearing pools below Norris Dam, Anderson Co. June 26, 1938, Bold.

Order OEDOGONIALES

Family *Oedogoniaceae*

Bulbochaete Agardh 1817

1. *Bulbochaete minor* A. Braun—N. C., on *Sphagnum* sp. beside Toxaway River, Transylvania Co. June 6, 1939, H-104.

Oedogonium Link 1820

1. *Oedogonium crenulatocostatum* Wittr.—TENN., Buffalo Springs, Grainger Co. June 26, 1938, B-14a & b.
2. *O. decipiens* var. *dissimile* (Hirn) Tiff.—N. C. on *Sphagnum* sp. at edge of Toxaway River, Transylvania Co. June 6, 1939, H-104.
3. *O. Hirnii* Gutw.—TENN., in ditch near Cosby, Cocke Co. July 17, 1939, H-366.
4. *O. irregulare* var. *condensatum* (Hallas) Hirn—S. C., on wooden dock at Brown's Lake, Mt. Rest. Oconee Co. June 12, 1939, B-124.
5. *O. multisporum* Wood—N. C., on *Sphagnum* sp. at edge of Toxaway River, Transylvania Co. June 6, 1939, H-104.
6. *O. plagiostomum* Wittr.—TENN., permanent pond north of Tazewell, Claiborne Co. June 26, 1939, Bold.

Order SIPHONOCLADALES

Family *Cladophoraceae*

Basicladia Hoffman & Tilden 1930

1. *Basicladia chelonum* (Coll.) Hoff. & Tilden—TENN., from turtle in pond near Kimberlin Heights, Knox Co. June 22, 1938.

Cladophora Kuetzing 1843

1. *Cladophora crispata* (Roth) Kuetz.—TENN., limestone pools at entrance of small stream to Norris Lake in Cove Creek inlet, Campbell Co. April 12, 1947, S-628.

Pithophora Wittrock 1877

1. *Pithophora varia* Wille—TENN., aquarium at University of Tennessee, May 16, 1947, S-692.

Rhizoclonium Kuetzing 1843

1. *Rhizoclonium crispum* Kuetz.—TENN., aquarium at University of Tennessee Botany Department, Knoxville, Knox Co. July 7, 1938, Bold.

Order SIPHONALES

Family *Vaucheriaceae*

Dichotomosiphon Ernst 1902

1. *Dichotomosiphon tuberosus* (A. Braun) Ernst—TENN., Montvale Springs Lake, Blount Co. June 30, 1931, Bold.

Vaucheria DeCandolle 1803

1. *Vaucheria arrhyncha* Heid.—S. C., on moist rocks in Eastatoe River, Oconee Co. July 2, 1939, H-267.
2. *V. geminata* f. *racemosa* (Vaucher) Walz—TENN., in shallows of brook, Deacon Creek, Brentwood, Williamson Co. Dec. 30, 1938, B-3914.
3. *V. repens* Hassall—TENN., dam at Centennial Park Lake, Nashville, Davidson Co. Nov. 3, 1938, B-182.
4. *V. sessilis* (Vaucher) De Cand.—TENN., in stream running over bank beside road near Sugarlands C. C. C. Camp site, elv. 1600 ft., Sevier Co. April 20, 1947.
5. *V. terrestris* Lyngbye—N. C., on wet rocks below Lickstone Bald, Haywood Co. July 17, 1939, H 363. (The only other report from southeastern United States was from the same state by Whitford, 1943.)

Order ZYGNEMATALES

Family *Zygnemataceae*

Spirogyra Link 1820

1. *Spirogyra communis* (Hassall) Kuetz.—N. C., on dripping rock, Jackson Co. June 1, 1939, H-85.
2. *S. denticulata* Trans.—TENN., floating in calcareous rock pool near highway U. S. 70, Rutherford Co. May 17, 1939, B-2937.
3. *S. laxa* Kuetz.—N. C., on vegetation near dock on Sapphire Lake, Jackson Co. June 9, 1939, H-114.
4. *S. longata* (Vaucher) Kuetz.—N. C., on vegetation near dock on Sapphire Lake, Jackson Co. June 9, 1939, H-114.

5. *S. miamiana* Taft—FLA., attached to submerged tin can near shore of Ashby Lake, Volusia Co. June 16, 1941, GP-3.
6. *S. parvula* (Trans.) Czurda—N. C., Small Lake, Macon Co. June 20, 1939, Bold.
7. *S. Spreeiana* Rab.—TENN., pool near Glen Echo Lake, Davidson Co. Feb. 19, 1939, B-3935.

Zygogonium Kuetzing 1843

1. *Zygogonium ericetorum* Kuetz.—TENN., in frozen puddle on Sugarlands Mountain trail near Mt. Collins, Sevier Co. Dec. 7, 1946, S-452.

Family *Mesotaeniaceae*

Cylindrocystis Meneghini 1838

1. *Cylindrocystis americana* West & West—FLA., on submerged vegetation in Ashby Lake, Volusia Co. June 15, 1941, GP-1.
2. *C. Brebissonii* Menegh.—N. C., in brownish floating gelatinous masses in shallow water of Ravenel Lake, Macon Co. May 12, 1939, H-35.

Mesotaenium Naegeli 1849

1. *Mesotaenium chlamydosporum* var. *minor* Reinsch—N. C., at dam on Phillips Lake, Macon Co. May 15, 1939, H-46.
2. *M. Greyi* Turner—N. C., on mosses in dripping cliffs at Buttermilk Falls, Macon Co. June 18, 1939, H-170.
3. *M. macrococcum* (Kuetz.) Roy—TENN., on wet *Thuidium* sp. at Carter's Farm, elv. 1100 ft., Knox Co. Oct., 1947, Silva (Iltis)-700.
4. *M. mirificum* Archer—N. C., rock pools on summit of Whiteside Mt., Jackson Co. June 4, 1939, H-96.

Roya West & West 1898 emend. Hodgetts 1920

1. *Roya obtusa* var. *montana* Gutw.—TENN., in rock pools at Ramsey Cascade, elv. 4150 ft., Sevier Co. July 18, 1939, H-334.

Spirotaenia de Brébisson 1848

1. *Spirotaenia eboracensis* West apud. Luetkemueller—S. C., east-facing cliff dripping with water, near Walhalla, Oconee Co. May 21, 1939, H-61.

Family *Desmidiaceae*

Arthrodesmus Ehrenberg 1838

1. *Arthrodesmus incus* var. *validus* West & West—FLA., on submerged vegetation in Ashby Lake, Volusia Co. June 15, 1941, GP-1. (The only other report from southeastern United States was made from the same state by West & West, 1898.)

Closterium Nitzsch 1817

1. *Closterium acerosum* (Schrank) Ehr.—TENN., loose coating on marble pebbles in spring at Fountain City Park, Knox Co. Mar. 23, 1946, S-549.
2. *C. didymotocum* Corda—N. C., in brown debris at Ravenel Lake, Macon Co. May 13, 1939, H-36.
3. *C. incurvum* Bréb.—N. C., High Hampton Lake, Jackson Co. June 2, 1939, H-87.
4. *C. intermedium* Ralfs—N. C., on shallow bottom of Philips Lake, Macon Co. May 15, 1939, H-49.
5. *C. juncidum* Ralfs—N. C., on shallow bottom of Philips Lake, Macon Co. May 15, 1939, H-49.
6. *C. Kuetzingii* var. *vittatum* Nordst—FLA., on submerged vegetation in Ashby Lake, Volusia Co. June 15, 1939, GP-1.
7. *C. moniliferum* (Bory) Ehr.—TENN., in branch two miles below Norris Dam, Anderson Co. June 26, 1939, B-12.
8. *C. parvulum* var. *angustum* West & West—FLA., in plankton sample from Ashby Lake, Volusia Co. June 15, 1941, GP-2. (The other report from the state was by West & West, 1898.)
9. *C. pusillum* Hantzsch—N. C., pools at the summit of Yellow Mountain, elv. 5200 ft., Jackson Co. June 14, 1939, H-139.
10. *C. Ralfsii* var. *Imanne* Cush.—N. C., arm of Sapphire Lake causing red coloring of water, Jackson Co. June 9, 1939, H-177; S.C., at shore at upper end of Brown's Lake, Mt. Rest, Oconee Co. June 12, 1939, H-125.
11. *C. toxon* W. West—S. C., at shore of Brown's Lake, Mt. Rest, Oconee Co. June 12, 1939, H-125.
12. *C. tumidum* Johnson—S. C., branch in field by Walhalla Road, Oconee Co. May 21, 1939, H-60.
13. *C. ulna* Focke—N. C., Sapphire Lake, Jackson Co. June 9, 1939, H-117; S. C., pool near Bull Pen Road Bridge over Chattooga River, Oconee Co. July 30, 1939, H-386.
14. *C. Venus* Kuetz.—TENN., Hidden Lake, Davidson Co. Sept. 17, 1938, B-103.

Cosmarium Corda 1834

1. *Cosmarium angulosum* Bréb.—FLA., on submerged aquatics and on ground at edge of small lake near Osteen, Volusia Co. June 15, 1941, GP-9.
2. *C. Baileyi* Wolle—TENN., Chilowee Park Lake at Knoxville, Knox Co. July 15, 1938, Bold.
3. *C. isthmium* West—N. C., High Hampton Lake, pH 7.2, Jackson Co. June 2, 1939, H-87.
4. *C. Lundellii* var. *ellipticum* West—N. C., Ravenel Lake, Macon Co. May 13, 1939, H-37.
5. *C. microsphinctum* Nordst.—GA., east-facing cliff by Walhalla Road, Rabun Co. May 21, 1939, H-61.

6. *C. ocellatum* Eich. & Gutw.—GA., west-facing cliff by Walhalla Road, Rabun Co. May 21, 1939, H-62.
   Flagler Beach, Flagler Co. June 16, 1941, GP-10.
7. *C. orthostichum* var. *pumilum* Lund.—FLA., on vegetation in pond near Osteen, Volusia Co. June 15, 1941, GP-7.
8. *C. Pokornyanum* (Grunow) West & West—N. C., on west-facing cliff, Jackson Co. May 7, 1939, H-33.
9. *C. Portianum* var. *nephroideum* Wittr.—FLA., on submerged aquatics and on the ground at edge of small lake near Osteen, Volusia Co. June 15, 1941, GP-9.
10. *C. punctulatum* Bréb.—TENN., Miss Littleton's lily pool, Kingston, Roane Co. July 8, 1938, Bold.
11. *C. reniforme* (Ralfs) Arch.—TENN., pond on Maryville Pike near city limits of Knoxville, Knox Co. June 30, 1931, Bold.
12. *C. subcucumis* Schm.—N. C., Ravenel Lake, Macon Co. May 24, 1939, H-82; FLA., small pond near Florida state highway 28, Flagler Co. June 16, 1941, GP-10.
13. *C. subtumidum* Nordst.—MISS., in big water fountain near Post Office, Vicksburg, Warren Co. Sept. 2, 1945, Delzie Demaree-25478.
14. *C. undulatum* var. *minutum* Wittr.—N. C., on wet west-facing cliff, Jackson Co. May 7, 1939, H-33.
15. *C. undulatum* var. *Wollei* West—GA., east-facing cliff by Walhalla Road, Rabun Co. May 21, 1939, H-61.

Desmidium Agardh 1825

1. *Desmidium Baileyii* var. *minor* Allorge & Allorge—FLA., on submerged vegetation in Ashby Lake, Volusia Co. June 15, 1941, GP-1; TENN., Miss Littleton's lily pool, Kingston, Roane Co. July 8, 1938, Bold.
2. *D. Grevillii* (Kuetz.) De Bary—FLA., attached to submerged vegetation in pond near Osteen, Volusia Co. June 15, 1941, GP-4.

Euastrum Ehrenberg 1832 emend. Ralfs 1844

1. *Euastrum binale* var. *Groenbladii* Krieger—FLA., on submerged vegetation in Ashby Lake, Volusia Co. June 15, 1941, GP-1.
2. *E. crassum* var. *scrobiculatum* Lund.—FLA., attached to submerged vegetation in pond near Osteen, Volusia Co. June 16, 1941, GP-4.
3. *E. didelta* (Turpin) Ralfs—N. C., ditch in field at Hull Home, Macon Co. June 1, 1939, H-90.
4. *E. insigne* var. *lobatum* Prescott & Scott—FLA., attached to submerged vegetation in pond near Osteen, Volusia Co. June 16, 1939, GP-4.
5. *E. oblongum* (Grev.) Ralfs—TENN., permanent pond north of Tazewell, Claiborne Co. June 26, 1938, Bold.
6. *E. sinuosum* Lenor.—N. C., on seeping rocks by Toxaway River, Transylvania Co. June 6, 1939, H-104.

7. *E. Turnerii* West—N. C., High Hampton Lake, Jackson Co. June 2, 1939, H-87.
8. *E. validum* West & West—FLA., on vegetation in pond near Osteen, Volusia Co. June 15, 1941, GP-5.
9. *E. verrucosum* var. *sublatum* Bréb.—FLA., attached to submerged vegetation in pond near Osteen, Volusia Co. June 15, 1941, GP-4.

Gymnozyga Ehrenberg 1841

1. *Gymnozyga Brebissonii* (Kuetz.) Wille—FLA., attached to submerged vegetation in pond near Osteen, Volusia Co. June 16, 1941, GP-4.

Hyalotheca Ehrenberg 1841

1. *Hyalotheca dissiliens* (Smith) Bréb.—TENN., McMinnville, Warren Co. Feb. 7, 1938, Bold (Miss Mason).
2. *H. mucosa* (Dillw.) Ehr.—TENN., Lakeside Pond, Sevierville Pike, Knox Co. July 11, 1938.
3. *H. mucosa* var. *minor* Roy—FLA., attached to submerged vegetation in pond near Osteen, Volusia Co. June 16, 1941, GP-4.
4. *H. undulata* Nordst.—FLA., on vegetation in pond near Osteen, Volusia Co. June 15, 1941, GP-7.

Micrasterias Agardh 1827

1. *Micrasterias americana* (Ehr.) Ralfs—TENN., McMinnville, Warren Co. Jan. 2, 1938, Bold (Miss Mason).
2. *M. apiculata* (Ehr.) Menegh.—VA., edge and bottom of old reservoir at University of Virginia at Charlottesville, Albemarle Co. Oct. 7, 1939, Strickland (G. H. Binnoveld); TENN., McMinnville, Warren Co. Jan. 2, 1938, Bold (Miss Mason).
3. *M. denticulata* var. *angustosinuata* Gay—N. C., ditch in field near Hull Home, Macon Co. June 1, 1939, H-90.
4. *M. depauperata* var. *Wollei* Cush.—FLA., on vegetation in pond near Osteen, Volusia Co. June 15, 1939, GP-7.
5. *M. muricata* (Bailey) Ralfs—N. C., Sapphire Lake, Jackson Co. June 9, 1939, Bold.
6. *M. muricata* var. *simplex* Groen.—FLA., on submerged aquatics and on ground at edge of small lake near Osteen, Volusia Co. June 15, 1939, GP-9.
7. *M. oscitans* Ralfs—N. C., in swamp by Watauga River, Watauga Co., summer 1939, H-700a.
8. *M. oscitans* var. *mucronata* (Dixon) Wille—FLA., in plankton sample from Ashby Lake, Volusia Co. June 16, 1941, GP-2.
9. *M. radiata* Hassall—TENN., Miss Littleton's lily pool at Kingston, Roane Co. July 11, 1938, Bold.
10. *M. radiata* var. *gracillima* G. M. Smith—FLA., attached to submerged vegetation in pond near Osteen, Volusia Co. June 16, 1941, GP-4.
11. *M. radiosa* Ralfs—N. C., Sapphire Lake, Jackson Co. June 9, 1939, H-117.

12. *M. radiosa* var. *ornata* Nordst.—S. C., in plankton from Brown's Lake, Mt. Rest, Oconee Co. May 21, 1939, and June 12, 1939, Bold.
13. *M. truncata* (Corda) Bréb.—TENN., Miss Littleton's lily pool at Kingston, Roane Co. July 11, 1938, Bold.
14. *M. truncata* var. *granulata* Racib.—N. C., Ravenel Lake, Macon Co. May 10, 1939, and May 13, 1939, H-37.
15. *M. truncata* var. *tridentata* Krieger—FLA., on submerged vegetation in Ashby Lake, Volusia Co. June 15, 1941, GP-1.

Onychonema Wallich 1860

1. *Onychonema laeve* var. *latum* West & West—FLA., attached to submerged vegetation in pond near Osteen, Volusia Co. June 16, 1941, GP-4.

Penium de Brébisson 1844

1. *Penium cucurbitinum* Bissett—FLA., on vegetation in pond near Osteen, Volusia Co. June 15, 1941, GP-7.
2. *P. cylindrus* (Ehr.) Bréb.—N. C., gelatinous coating on wet rocks at Bridal Veil Falls, Macon Co. May 14, 1939, H-41a.
3. *P. libellula* (Focke) Nordst.—N. C., shallow water in upper Sapphire Lake, Jackson Co., June 9, 1939, H-117.
4. *P. Margaritaceum* (Ehr.) Bréb.—TENN., roadside pool, Jefferson Co. June 26, 1938, Bold.
5. *P. spirostriolatum* Barker—N. C., rock pools at the summit of Yellow Mountain, Jackson Co. June 14, 1939, H-142.

Phymatodocis Nordstedt 1877

1. *Phymatodocis Nordstedtiana* Wolle—VA., thick gelatinous masses attached to *Utricularia* sp. in slow-moving water of small pond run-off 10 miles south of Fredericksburg, Caroline Co. Sept. 9, 1947, Iltis-3692.

Pleurotaenium Naegeli 1849

1. *Pleurotaenium maximum* (Reinsch) Lund.—N. C., Ravenel Lake, Macon Co. May 13, 1939, H-37.
2. *P. minutum* (Ralfs) Delp.—N. C., shallow bottom in Phillips Lake, Macon Co. May 15, 1939, H-43.
3. *P. minutum* var. *elongatum* West & West—FLA., on submerged vegetation in Ashby Lake, Volusia Co. June 15, 1941, GP-1.
4. *P. minutum* var. *major* Lund—FLA., attached to submerged vegetation in pond near Osteen, Volusia Co. June 16, 1941, GP-4.
5. *P. nodosum* (Bailey) Lund.—N. C., in swamp along Cave Creek, Haywood Co. July 17, 1939, H-362.
6. *P. trabecula* (Ehr.) Naeg.—TENN., roadside pool, Jefferson Co. June 26, 1938, Bold.
7. *P. trochiscum* var. *tuberculatum* G. M. Smith—FLA., on vegetation in pond near Osteen, Volusia Co. June 15, 1941, GP-5.

Spondylosium de Brébisson 1844

1. *Spondylosium pygmaeum* (Rab.) West—N. C., swamp along Watauga River, Watauga Co. summer 1939, H-700a.

Staurastrum Meyen 1829

1. *Staurastrum anatinum* var. *longibrachiatum* West & West—FLA., on submerged aquatics and on ground at edge of small lake near Osteen, Volusia Co. June 15, 1941, GP-9.
2. *S. Archerii* West—FLA., on vegetation in pond near Osteen, Volusia Co. June 15, 1941, GP-7.
3. *S. brasiliense* var. *Lundellii* West & West—S. C., Brown's Lake, pH 6.6 at Mt. Rest, Oconee Co. June 12, 1939, H-125.
4. *S. capitulum* Bréb.—N. C., Bridal Veil Falls, Macon Co. May 14, 1939, H-41.
5. *S. connatum* (Lund.) Roy & Bissett—FLA., small pond near Florida state highway 28 near Flagler Beach, Flagler Co. June 16, 1939, GP-10.
6. *S. elongatum* var. *quadratum* Irénée-Marie—FLA. on submerged aquatics and on ground at edge of small lake near Osteen, Volusia Co. June 15, 1941, GP-9.
7. *S. furcatum* var. *pisciforme* Turner—FLA., small pond near Florida state highway 28 near Flagler Beach, Flagler Co. June 16, 1941, GP-10.
8. *S. gladiosum* Turner—N. C., Fox Swamp, Macon Co. June 2, 1939, H-102.
9. *S. gracile* var. *nanum* Wille—FLA., attached to submerged vegetation in pond near Osteen, Volusia Co. June 16, 1941, GP-4.
10. *S. gracile* var. *tenuissimum* Boldt—FLA., on vegetation in pond near Osteen, Volusia Co. June 15, 1941, GP-5.
11. *S. grande* Bulnh.—S. C., Brown's Lake, pH 6.6, Mt. Rest, Oconee Co. May 21, 1939, Bold.
12. *S. grande* var. *parvum* West—FLA., on submerged aquatics and on ground at edge of small lake near Osteen, Volusia Co. June 15, 1941, GP-1.
13. *S. gyrans* Johnson—FLA., small pond near Florida state highway 28 near Flagler Beach, Flagler Co. June 16, 1941, GP-10.
14. *S. hexacerum* (Ehr.) Wittr.—N. C., Bridal Veil Falls, Macon Co. May 14, 1939, H-41; FLA., on vegetation in pond near Osteen, Volusia Co. June 15, 1941, GP-7.
15. *S. lacustre* G. M. Smith—FLA., on submerged aquatics and on ground at edge of small lake near Osteen, Volusia Co. June 15, 1941, GP-9.
16. *S. Meriani* Reinsch.—N. C., on rocks near highway U. S. 64, Macon Co. June 1, 1939, H-83.
17. *S. muticum* Bréb.—N. C., plankton from High Hampton Lake, Jackson Co. June 2, 1939, H-86a.
18. *S. ophiura* var. *minus* Prescott & Scott—FLA., on vegetation in pond near Osteen, Volusia Co. June 15, 1941, GP-5.
19. *S. orbiculare* var. *hibernicum* W. West—FLA., attached to submerged vegetation in pond near Osteen, Volusia Co. June 16, 1941, GP-4.

20. *S. pachyrhynchum* Nordst.—FLA., on submerged aquatics and on ground at edge of small lake near Osteen, Volusia Co. June 15, 1941, GP-9.
21. *S. paradoxum* Meyen—TENN., Chilowee Park Lake at Knoxville, Knox Co. July 15, 1938, Bold.
22. *S. pyramidatum* West—FLA., on submerged vegetation in Ashby Lake, Volusia Co. June 15, 1941, GP-1.
23. *S. turgescens* de Not.—N. C., on wet west-facing cliff, Jackson Co. May 7, 1938, H-33.

Tetmemorus Ralfs 1844

1. *Tetmemorus Brebissonii* var. *minor* De Bary—FLA., attached to submerged vegetation in pond near Osteen, Volusia Co. June 16, 1941, GP-4.
2. *T. granulatus* (Bréb.) Ralfs—N. C., pasture pools near Phillips Lake, Macon Co. May 15, 1939, H-53.

Xanthidium Ehrenberg 1837

1. *Xanthidium antilopaeum* var. *polymazum* Nordst.—N. C., in shallow water on east side of Phillips Lake, Macon Co. May 15, 1939, H-43.
2. *X. armatum* (Bréb.) Rab.—N. C., on seeping rocks in Toxaway River, Transylvania Co. June 6, 1939, H-104.
3. *X. armatum* var. *mediolaeve* G. M. Smith—FLA., in small pond near Florida state highway 28 near Flagler Beach, Flagler Co. June 16, 1941, GP-10.
4. *X. pseudobengalicum* Groenb.—FLA., in small pond near Florida state highway 28 near Flagler Beach, Flagler Co. June 16, 1941, GP-10.
5. *X. Robinsonianum* var. *parvulum* Skuja—FLA., in small pond near Florida state highway 28 near Flagler Beach, Flagler Co. June 16, 1941, GP-10.

Order CHARALES

Family *Characeae*

Chara Linnaeus 1754

1. *Chara gymnopus* A. Braun—VA., growing in sand at edge of Shenandoah River, Warren Co. Sept. 9, 1945, H. G. Diegman-701.

Phylum EUGLENOPHYTA

Class **Euglenophyceae**

Order EUGLENALES

Family *Euglenaceae*

Euglena Ehrenberg 1838

1. *Euglena acutissima* Lemm.—TENN., pond on old Sevierville Pike near Kimberlin Heights, Knox Co. June 22, 1938, Bold.
2. *E. deses* Ehr.—S. C., Brown's Lake at Mt. Rest, Oconee Co. May 21, 1939, H-69a.
3. *E. gracilis* Klebs—TENN., Sanford Estate at Knoxville, Knox Co. July, 1938, Bold.

4. *E. polymorpha* Dang.—N. C., Phillips Lake, Macon Co. May 15, 1939, H-49.
5. *E. splendens* Dang.—TENN., Andrew Jackson (Dead Horse) Lake, Knox Co. July 7, 1938, Bold.
6. *E. tripteris* (Duj.) Klebs—TENN., Chilowee Park Lake at Knoxville, Knox Co. June 26, 1938, Bold.

Phacus Dujardin 1841

1. *Phacus caudatus* Hueb.—TENN., Montvale Springs Lake, Blount Co. June 30, 1931, Bold.
2. *P. orbicularis* Hueb.—TENN., Chilowee Park Lake at Knoxville, Knox Co. June 29, 1938.

Phylum PYRROPHYTA

Class **Dinophyceae**

Order PERIDINIALES

Family *Gonyaulaceae*

Gonyaulax Diesing 1866 emend. Kofoid 1911

1. *Gonyaulax palustris* Lemm.—TENN., Fountain City Park Lake, Knox Co. July 12, 1938, Bold.

Phylum RHODOPHYTA

Class **Rhodophyceae**

SUB-CLASS PROTOFLORIDEAE

Order BANGIALES

Family *Porphyridiaceae*

Porphyridium Naegeli 1849

1. *Porphyridium cruentum* Naeg.—TENN., on wet sand in greenhouse at University of Tennessee at Knoxville, Knox Co. May 7, 1947, S-694.

SUB-CLASS FLORIDEAE

Order NEMALIONALES

Family *Batrachospermaceae*

Batrachospermum Roth 1797

1. *Batrachospermum Boryanum* Sirodot—TENN., Carter's Mill Spring, Knox Co. April 2, 1947, S-572.
2. *B. densum* Sirodot—TENN., Fountain City Park Lake, Knox Co. July 12, 1938, Bold.
3. *B. moniliforme* Roth—TENN., in small sluiceway from stream running through gravel and peat on Porter's Prong, elv. about 3300 ft., Sevier Co. Sept. 4, 1941, S-155.

4. *B. sporulans* Sirodot—N. C., on rocks in culvert three miles west of Highlands, Macon Co. May 15, 1939, H-45.

Lemanea Bory 1808 emend. Agardh 1838

1. *Lemanea* (*Sacheria*) *fluviatilis* Agardh.—TENN., on sandstone brink of Falls Creek Falls, Van Buren Co. May 4, 1947, S-668.

Tuomeya Harvey 1858

1. *Tuomeya fluviatilis* Harvey—TENN., on sandstone brink of Falls Creek Falls, Van Buren Co. May 4, 1947, S-668.

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SOME PROPERTIES OF THE GENERALIZED LOGOCYCLIC CURVE AND CERTAIN ASSOCIATED CURVES

By L. L. Garner

Department of Mathematics, University of North Carolina
Chapel Hill, North Carolina

1. *Introduction.* Consider the plane curve λ_t whose rectangular coordinates are given as follows:

$$x = \rho \cos (t\theta), \qquad y = \rho \sin (t\theta); \tag{1}$$

where $\rho = a (\sec \theta \pm \tan \theta)$, a is a positive constant, θ is a variable such that $-\dfrac{\pi}{2} \leqq \theta \leqq \dfrac{\pi}{2}$, t is a real number. It is sufficient to take $t \geqq 0$, since θ may assume negative values. For a given value of t, equations (1) represent a curve symmetric with respect to the x-axis, passing through the origin, and having a double point at $(a, 0)$. For $t = 0$, the curve λ_0 is the positive half of the x-axis, including the origin.

From the definition of ρ, it is evident that for a given t and θ, equations (1) give two points of the curve λ_t. If we let ρ and $\bar{\rho}$ represent $a (\sec \theta + \tan \theta)$ and $a (\sec \theta - \tan \theta)$, respectively, then (1) may be written as:

$$\begin{aligned} x &= \rho \cos (t\theta), \qquad y = \rho \sin (t\theta); \\ \bar{x} &= \bar{\rho} \cos (t\theta), \qquad \bar{y} = \bar{\rho} \sin (t\theta). \end{aligned} \tag{1'}$$

The two points $P(x, y)$ and $\bar{P}(\bar{x}, \bar{y})$ so defined are a pair of corresponding inverse points with respect to the circle $x^2 + y^2 = a^2$.

Associated with each λ_t curve, $t \neq 0$, are two other curves, Γ_t and Ω_t, analytically defined in section 2, below, but which may be intuitively described as follows: Γ_t denotes the locus of the point of intersection of the tangents to λ_t at a pair of corresponding inverse points P and $\bar{P}$ as θ varies over its range; Ω_t represents the locus of the point of intersection of the corresponding normals.

James Booth[1] has found some interesting relations among the three curves λ_t, Γ_t and Ω_t when $t = 1$. As we shall show later, in section 2, these are the *logocyclic curve,*[2] the cissoid and the parabola, respectively (see figure 1). In fact, the λ_1 curve is commonly designated the strophoid; but Booth more appropriately called it the logocyclic curve on account of its relation to the theory of logarithms. Since we are dealing with a generalization of these three curves, it seems fitting to call λ_t the *generalized logocyclic curve.*

2. *Tangents and normals.* We now derive analytical expressions defining Γ_t and Ω_t. Using equations (1'), and letting t be fixed, we find that

[1] James Booth: Some New Geometrical Methods, Vol. I, Longmans, Green, 1873.
[2] *Ibid.*

$$dy = \rho[\sec\theta \sin(t\theta) + t\cos(t\theta)]\, d\theta,$$
$$dx = \rho[\sec\theta \cos(t\theta) - t\sin(t\theta)]\, d\theta,$$

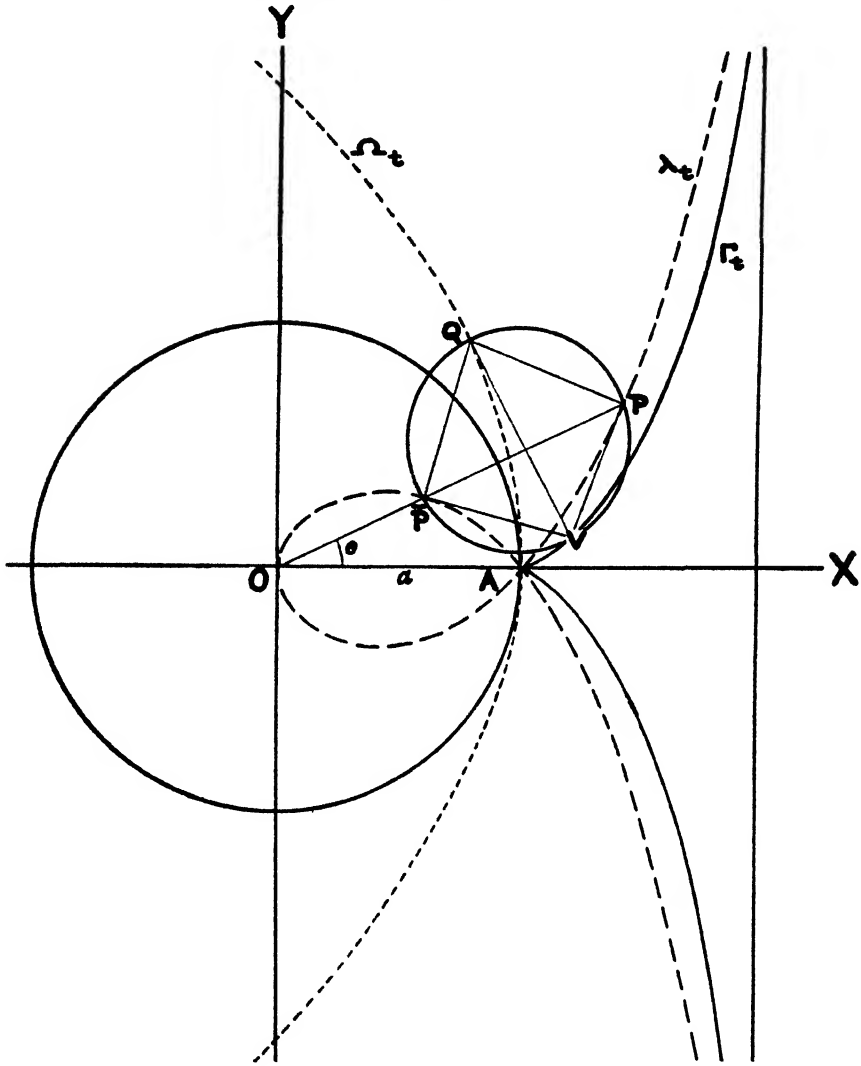


FIG. 1

since $d\rho = a(\sec\theta\tan\theta + \sec^2\theta)d\theta = \rho\sec\theta\, d\theta$. Therefore, the slope of the tangent to λ_t at $P(x, y)$ is

$$\frac{dy}{dx} = \frac{t + \sec\theta\tan(t\theta)}{\sec\theta - t\tan(t\theta)}, \qquad -\frac{\pi}{2} < \theta < \frac{\pi}{2}.$$

Similarly, it may be seen that

$$\frac{d\bar{y}}{d\bar{x}} = \frac{\sec\theta\tan(t\theta) - t}{\sec\theta + t\tan(t\theta)}.$$

If (X, Y) denotes a variable point on the tangents, then the equation of the tangent at P is $AX + BY = C$, and at $\bar{P}$ it is $\bar{A}X + \bar{B}Y = \bar{C}$, where

$$\begin{aligned} A &= t + \sec\theta \tan(t\theta), & B &= t\tan(t\theta) - \sec\theta, & C &= \rho t \sec(t\theta); \\ \bar{A} &= t - \sec\theta\tan(t\theta), & \bar{B} &= t\tan(t\theta) + \sec\theta, & \bar{C} &= \bar{\rho} t\sec(t\theta). \end{aligned}$$

Solving this system of equations for X and Y, we obtain

$$\text{(2)} \qquad \begin{aligned} X &= a[\sec\theta\cos(t\theta) + t\sin\theta\sin(t\theta)], \\ Y &= a[\sec\theta\sin(t\theta) - t\sin\theta\cos(t\theta)]. \end{aligned}$$

For a given t, equations (2) are the parametric representation of the Γ_t curve associated with the given λ_t. ∎

In like manner, if (ξ, η) denotes a variable point on the normals to a λ_t at a pair of corresponding inverse points, the equations of the normals are

$$B\xi - A\eta = C' \text{ and } \bar{B}\xi - \bar{A}\eta = \bar{C}',$$

where

$$C' = -\frac{C}{t}\sec\theta \text{ and } \bar{C}' = \frac{\bar{C}}{t}\sec\theta.$$

Solving this system, we get

$$\text{(3)} \qquad \begin{aligned} \xi &= \frac{a}{t}\sec\theta\,[t\cos(t\theta) - \tan\theta\sin(t\theta)], \\ \eta &= \frac{a}{t}\sec\theta\,[\tan\theta\cos(t\theta) + t\sin(t\theta)], \end{aligned}$$

as the parametric representation of the corresponding Ω_t curve, if $t \neq 0$.

Putting $t = 1$ in (1), (2) and (3), one easily obtains

$$\begin{aligned} \lambda_t:&\ x = a(1 \pm \sin\theta), & y &= a(1 \pm \sin\theta)\tan\theta; \\ \Gamma_1:&\ X = a(1 + \sin^2\theta), & Y &= a\sin^2\theta\tan\theta; \\ \Omega_1:&\ \xi = a(1 - \tan^2\theta), & \eta &= 2a\tan\theta. \end{aligned}$$

More familiar forms are obtained by eliminating θ, and using x and y in each case. They are
$(x^2 + y^2)(2a - x) = a^2x$; $(x - a)^3 = (2a - x)y^2$; and $y^2 = 4a(a - x)$, respectively.

3. *Theorems.* Let $V(X, Y)$ denote the point of intersection of the tangents to λ_t at a pair of corresponding inverse points P and $\bar{P}$; let $Q(\xi, \eta)$ represent the intersection of the normals at these points. We now prove the following

THEOREM I. *Any point V is equidistant from its pair of corresponding inverse points P and $\bar{P}$; likewise, Q is equidistant from P and $\bar{P}$.*

PROOF: The differences of the coordinates of V, P and $V, \bar{P}$ are

$$\begin{aligned} X - x &= a[t\sin\theta\sin(t\theta) - \tan\theta\cos(t\theta)], \\ Y - y &= -a[t\sin\theta\cos(t\theta) + \tan\theta\sin(t\theta)]; \\ X - \bar{x} &= a[t\sin\theta\sin(t\theta) + \tan\theta\cos(t\theta)], \\ Y - \bar{y} &= -a[t\sin\theta\cos(t\theta) - \tan\theta\sin(t\theta)]. \end{aligned}$$

Squaring and adding these in pairs, we have the relation

$$(X - x)^2 + (Y - y)^2 = (X - \bar{x})^2 + (Y - \bar{y})^2,$$

which proves the first part of the theorem. The second part is proved in a similar manner.

THEOREM II. *The tangent to Ω_t at Q is perpendicular to the chord $P\bar{P}$.*

PROOF: The slope of the tangent to Ω_t at Q is obtained as follows:

$$d\eta = \frac{a}{t}(t^2 + 1 + 2\tan^2\theta)\sec\theta\cos(t\theta)\,d\theta,$$

$$d\xi = -\frac{a}{t}(t^2 + 1 + 2\tan^2\theta)\sec\theta\sin(t\theta)\,d\theta.$$

From these we get

$$\frac{d\eta}{d\xi} = -\cot(t\theta).$$

But the slope of the chord $P\bar{P}$ is $\tan(t\theta)$. Therefore, the two lines are perpendicular.

COROLLARY I. *The tangent to Ω_t at Q passes through the corresponding V of Γ_t.*

The proof follows from theorems I and II. We also have the following

COROLLARY II. *Line segment VQ is a diameter of a circle passing through P and $\bar{P}$.*

We now prove the following

THEOREM III. *For a given pair of values of t and θ, not zero, the point Q lies on line $y = x\,[\tan(t + 1)\theta]$ if and only if $t = 1$.*

PROOF: Directly substituting ξ and η from equations (3) for x and y in the equation stated in the theorem, making use of the formula for the tangent of the sum of two angles, *and clearing* of fractions, we obtain

$$(t - 1)\sec\theta\tan\theta\sec(t\theta) = 0.$$

This equation is satisfied if and only if $t = 1$, provided $\theta \neq 0$.

It is interesting to see where Q is situated in general with respect to this line $y = x[\tan(t + 1)\theta]$, since Q lies on it if and only if $t = 1$. Let φ denote the inclination of the line through the origin and Q with respect to the x-axis. Let χ denote the inclination of the line determined by the origin and the corresponding point V. We now prove the following

LEMMA. *If $0 \leqq \theta \leqq \frac{\pi}{2}$, $t > 0$, then $0 \leqq \varphi - \chi \leqq \frac{\pi}{2}$.*

PROOF: That $\varphi - \chi \leqq \frac{\pi}{2}$ follows immediately from the fact that Q and V are the extremities of a diameter of a circle passing through P and $\bar{P}$, since the vertex of the angle $\varphi - \chi$, i.e., the origin, is never interior to the circle. Now, it is clear that

$$\tan\varphi = \frac{\eta}{\xi} = \frac{\frac{a}{t}\sec\theta[\tan\theta\cos(t\theta) + t\sin(t\theta)]}{\frac{a}{t}\sec\theta[t\cos(t\theta) - \tan\theta\sin(t\theta)]},$$

which reduces to

$$\tan \varphi = \frac{\tan \theta + t \tan(t\theta)}{t - \tan \theta \tan (t\theta)};$$

and

$$\tan \chi = \frac{a[\sec \theta \sin (t\theta) - t \sin \theta \cos (t\theta)]}{a[\sec \theta \cos (t\theta) + t \sin \theta \sin (t\theta))}$$
$$= \frac{2 \tan (t\theta) - t \sin 2\theta}{2 + t \sin 2\theta \tan (t\theta)}.$$

Using these results, one readily finds that

$$\tan (\varphi - \chi) = \frac{2 \tan \theta + t^2 \sin 2\theta}{2t - t \sin 2\theta \tan \theta}.$$

The numerator of this expression is certainly not negative if $0 \leq \theta \leq \frac{\pi}{2}$. For all positive values of t the denominator is not negative; because, if $\sin 2\theta$ be replaced by $2 \sin \theta \cos \theta$, the denominator may be written as

$$2t(1 - \sin^2 \theta) = 2t \cos^2 \theta \geqq 0.$$

It follows, therefore, that $\tan (\varphi - \chi) \geqq 0$; hence $0 \leqq \varphi - \chi \leqq \frac{\pi}{2}$, if $0 \leqq \theta \leqq \frac{\pi}{2}$. This proves the lemma.

We now prove the following

THEOREM IV. *If* $0 < \theta < \frac{\pi}{2}, t > 0$, *it follows that* $(t + 1)\theta \gtrless \varphi$ *according as* $t \gtrless 1$; *while for any* t, $\lim\limits_{\theta \to \pi/2} [(t + 1)\theta - \varphi] = 0$.

PROOF: Since Q and V lie on opposite sides of the chord $P\bar{P}$ for all θ such that $0 < \theta < \frac{\pi}{2}$, it follows from the lemma that $\chi < t\theta < \varphi$, from which it is easily shown that $(t + 1)\theta - \varphi \leqq \frac{\pi}{2}$. Now,

$$\tan [(t + 1)\theta - \varphi] = \frac{\tan [(t + 1)\theta] - \tan \varphi}{1 + \tan [(t + 1)\theta] \tan \varphi}$$

$$= \frac{\dfrac{\tan (t\theta) + \tan \theta}{1 - \tan (t\theta) \tan \theta} - \dfrac{\tan \theta + t \tan (t\theta)}{t - \tan \theta \tan (t\theta)}}{1 + \dfrac{\tan (t\theta) + \tan \theta}{1 - \tan (t\theta) \tan \theta} \cdot \dfrac{\tan \theta + t \tan (t\theta)}{t - \tan \theta \tan (t\theta)}}$$

$$= \frac{(t - 1) \tan \theta \sec^2 (t\theta)}{(t + \tan^2 \theta) \sec^2 (t\theta)} = \frac{t - 1}{t \cot \theta + \tan \theta}.$$

This expression agrees with $t - 1$ in algebraic sign. Finally, for a given value

of t, the limit approached as $\theta \to \frac{\pi}{2}$ is zero. This completes the proof.

It has just been shown that $\lim_{\theta \to \pi/2} \varphi = (t+1)\frac{\pi}{2}$, if $t > 0$. Now, draw a line through the origin inclined at an angle $(t+1)\theta$ with respect to the x-axis. Choose two points, R and S, on this line such that line segment $OR = \bar{\rho} \sec \theta$, and segment $OS = \rho \sec \theta$, where O denotes the origin. The following theorem is true:

THEOREM V.

$$\operatorname*{Lim}_{\theta \to \pi/2} \frac{OR + OS}{2\,OQ} = t\,, \textit{ provided } t \neq 0.$$

PROOF:

$$\frac{OR + OS}{2} = \frac{\bar{\rho} + \rho}{2} \sec \theta = a \sec^2 \theta, \text{ while line segment } OQ$$

$$= \frac{a}{t} \sec \theta \sqrt{t^2 + \tan^2 \theta}.$$

Therefore,

$$\lim_{\theta \to (\pi/2)} \frac{OR + OS}{2OQ} = \lim_{\theta \to (\pi/2)} \frac{t \sec \theta}{\sqrt{t^2 + \tan^2 \theta}} = \lim_{\theta \to (\pi/2)} \frac{t}{\sqrt{t^2 \cos^2 \theta + \sin^2 \theta}} = t.$$

COROLLARY III. *When $t = 1$, Q bisects line segment RS.*

4. *Behavior of λ_t, Γ_t and Ω_t for certain limiting values of θ.* It has already been noted that every λ_t curve passes through the point $(a, 0)$. This is also true concerning the Γ_t and the Ω_t curves, as is readily seen from equations (2) and (3) when $\theta = 0$, except that Ω_t does not exist when $t = 0$.

The behavior of λ_t and Γ_t as $\theta \to \pm \frac{\pi}{2}$ is more interesting. Because of symmetry, it is sufficient to consider when $\theta \to \frac{\pi}{2}$. Since

$$\lim_{\theta \to (\pi/2)} \bar{\rho} = a \lim_{\theta \to (\pi/2)} \frac{1 - \sin \theta}{\cos \theta} = \lim_{\theta \to (\pi/2)} \frac{-\cos \theta}{-\sin \theta} = 0,$$

point $\bar{P}$ approaches the origin. Since $\lim_{\theta \to \pi/2} \rho = \infty$, point P tends toward infinity. Moreover, since

$$\lim_{\theta \to (\pi/2)} \frac{dy}{dx} = \lim_{\theta \to (\pi/2)} \frac{t + \sec \theta \tan (t\theta)}{\sec \theta - t \tan (t\theta)} = \lim_{\theta \to (\pi/2)} \frac{t \cos \theta + \tan (t\theta)}{1 - \cos \theta \tan (t\theta)} = \tan \frac{\pi t}{2},$$

provided t is not an odd integer, the equation of the asymptote to λ_t is

$$\left(\sin \frac{\pi t}{2}\right) x - \left(\cos \frac{\pi t}{2}\right) y + c = 0,$$

where c is to be so determined that the numerical distance between the λ_t curve and this line tends to zero as $\theta \to \frac{\pi}{2}$. Putting the equation in normal form and substituting for x and y the values given in (1′), we express this distance as

$$d = \frac{a\,(\sec\theta + \tan\theta)\left[\sin\frac{\pi t}{2}\cos(t\theta) - \cos\frac{\pi t}{2}\sin(t\theta)\right] + c}{\sqrt{\sin^2\frac{\pi t}{2} + \cos^2\frac{\pi t}{2}}},$$

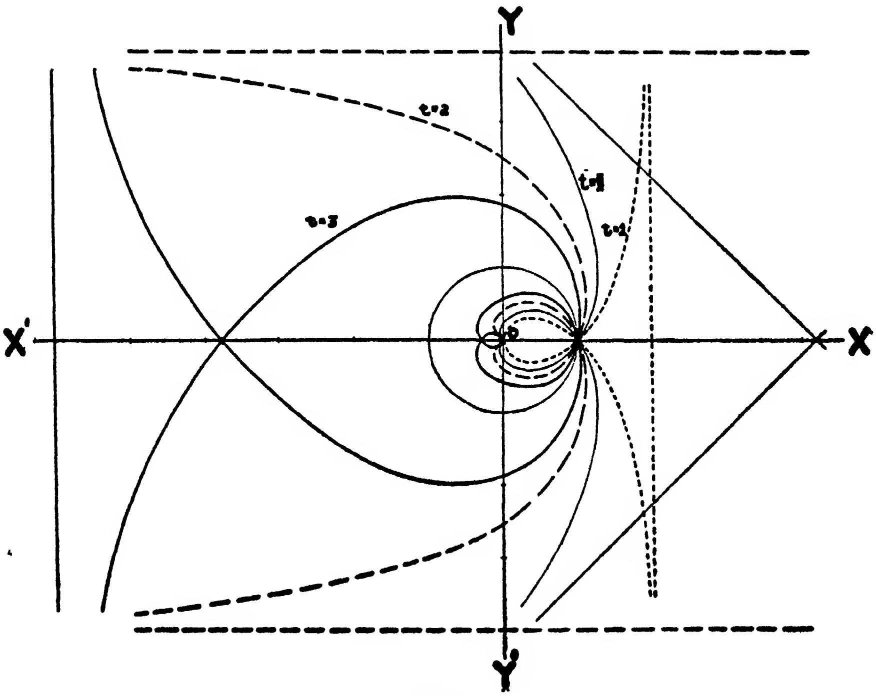


FIG. 2

which becomes

$$d = a\,(\sec\theta + \tan\theta)\sin\left(\frac{\pi t}{2} - t\theta\right) + c.$$

We now require $d \to 0$ as $\theta \to \frac{\pi}{2}$, and put

$$\begin{aligned} c &= a \lim_{\theta\to(\pi/2)} \left\{\frac{(1+\sin\theta)\sin\left[t\left(\theta - \frac{\pi}{2}\right)\right]}{\cos\theta}\right\} \\ &= a \lim_{\theta\to(\pi/2)} \left\{\frac{\cos\theta\sin\left[t\left(\theta-\frac{\pi}{2}\right)\right] + t\,(1+\sin\theta)\cos\left[t\left(\theta-\frac{\pi}{2}\right)\right]}{-\sin\theta}\right\} \\ &= -2at. \end{aligned}$$

It follows from symmetry that c becomes $2\,at$ as $\theta \to -\frac{\pi}{2}$. Thus the asymptotes to λ_t are

$$y = \pm\left(\tan\frac{\pi t}{2}\right)x \mp 2\,at\sec\frac{\pi t}{2},$$

the upper signs holding when $\theta \to \frac{\pi}{2}$, the lower signs, when $\theta \to -\frac{\pi}{2}$.

A like procedure leads to exactly the same equations as asymptotes to the corresponding Γ_t curve.

Horizontal and vertical asymptotes are obtained when t is an even and an odd integer, respectively.

Figure 2 shows the λ_t curves, with asymptotes, for the special cases $t = 1$, $\frac{3}{2}$, 2, and 3.

STUDIES IN THE LEGUMINOSAE

IV Chromosome Numbers and Geographical Relationships of Miscellaneous Leguminosae

By Earlene Atchison

The Blandy Experimental Farm
Boyce, Virginia[1]

The general stability of chromosome number in the Leguminosae has been studied on the specific, generic, and tribal levels by Senn (1938) and Atchison (1947a, 1947b, unpublished). This list of chromosome numbers is intended as a supplement to the data obtained by Senn on mostly temperate members of the family, which the author will later compare with data on the tropical groups.

Material for cytological study of 28 species was grown in the field and greenhouse at the Blandy Experimental Farm from seed or plants obtained from botanical gardens and collectors, or collected in the field by the author. All counts were made from acetic orcein leaf smears with the exception of *Ormosia panamensis*, which was studied from Feulgen root-tip sections. Leaves of the *Gleditsia* species were pretreated for one hour with a saturated aqueous solution of paradichlorobenzene. Drawings (Figs. 1–27) were made at a camera lucida magnification of approximately 5000 and reduced in reproduction to approximately 2500. Species name, source of material, general distribution and $2n$ chromosome number are included in Table 1.

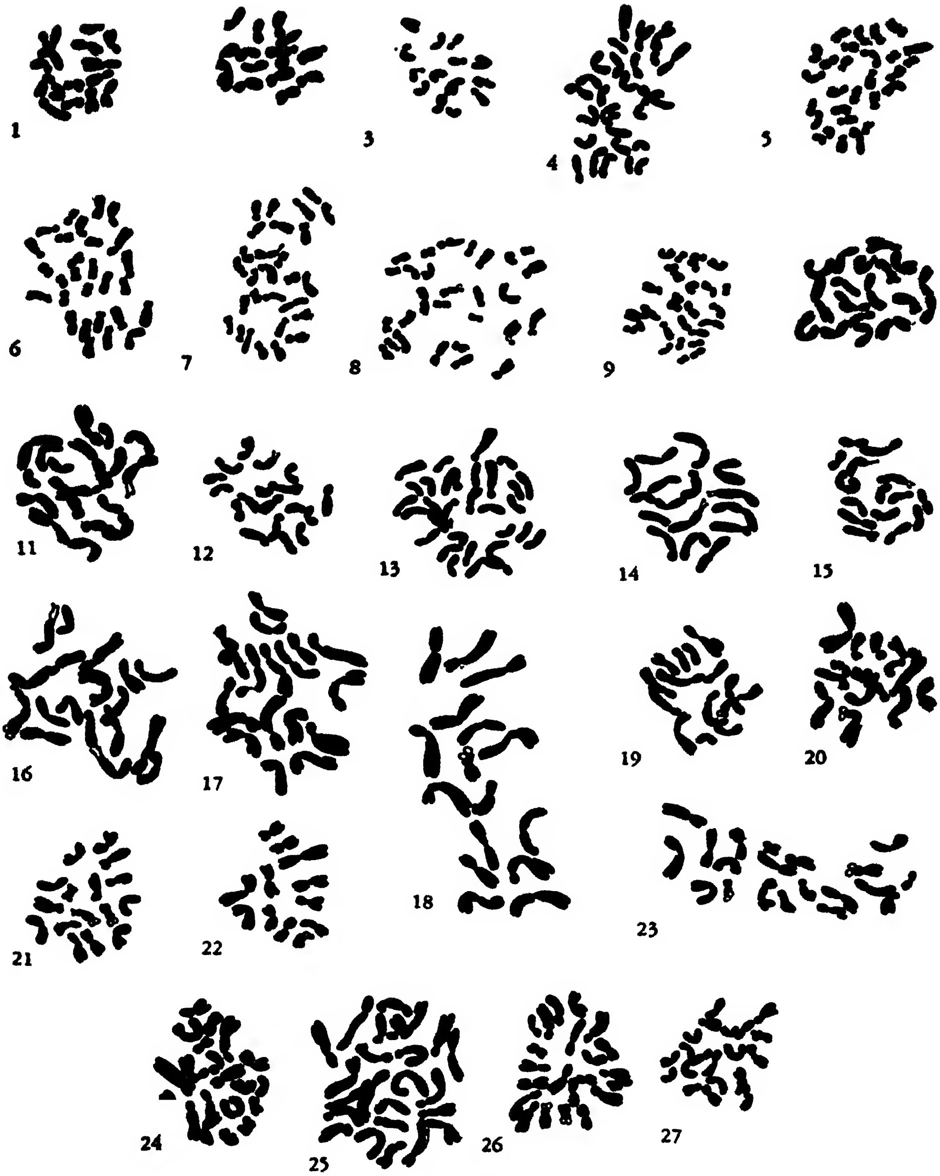
None of the chromosome counts, with the exception of *Gleditsia amorphoides* (Castronova, 1945), has been reported previously.

Various attempts have been made to correlate polyploidy within plant groups with climatic distribution. Hagerup (1932), and others found a positive correlation between northern distribution and polyploidy; Bowden (1940) found polyploids generally no more resistant to cold than diploids. Senn (1938) could not demonstrate a correlation of polyploidy with a wider or more northerly distribution in the Leguminosae. Because of the difficulty in determining the chromosome number level at which diploidy ceases and polyploidy begins, and because of the unavoidable variation in taxonomic species concepts among unrelated plant groups, it is difficult to interpret the climatic or geographical distribution of chromosome variations without special attention to the nature of the individual species.

Schrankia angustata is a shrubby briar of southeastern North America; *Calliandra inaequilatera* is a shrub from Bolivia. Although *S. angustata* is warm temperate and *C. inaequilatera* is tropical both have $2n = 16$ chromosomes, while the majority of the Mimosoideae are warm temperate or tropical, with $2n = 26$ chromosomes.

Among the Caesalpinioideae the woody temperate genera *Cercis*, *Gymno-*

[1] Author's present address is: Department of Botany, University of North Carolina. Chapel Hill, North Carolina.



Figs. 1–27. Chromosomes of miscellaneous Leguminosae. 1. *Schrankia angustata*, $2n = 16$. 2. *Calliandra inaequilatera*, $2n = 16$. 3. *Cercis occidentalis*, $2n = 14$. 4. *Gymnocladus dioica*, $2n = 28$. 5. *Gleditsia aquatica*, $2n = 28$. 6. *G. amorphoides*, $2n = 28$. 7. *G. heterophylla*, $2n = 28$. 8. *G. horrida*, $2n = 28$. 9. *G. sinensis*, $2n = 28$. 10. *Sophora tetraptera*, $2n = 18$. 11. *S. microphylla*, $2n = 18$. 12. *S. secundiflora*, $2n = 18$. 13. *Cladastris lutea*, $2n = 28$. 14. *Ormosia panamensis*, $2n = 16$. 15. *O. Krugii*, $2n = 16$. 16. *Podalyria australis*, $2n = 18$. 17. *Baptisia leucantha*, $2n = 18$. 18. *Caragana* sp. (*Boissoana?*), $2n = 16$. 19. *Dalea alopecuroides*, $2n = 14$. 20. *D. occidentalis*, $2n = 14$. 21. *Halimodendron argenteum*, $2n = 16$. 22. *Sesbania macrocarpa*, $2n = 12$. 23. *Stylosanthes riparia*, $2n = 20$. 24. *Zornia bracteata*, $2n = 20$. 25. *Coronilla glauca*, $2n = 24$. 26. *Rhynchosia erecta*, $2n = 22$. 27. *Galactia volubilis*, $2n = 20$.

TABLE 1

SPECIES	SOURCE OF MATERIAL	DISTRIBUTION	2n
Subfamily Mimosoideae			
Schrankia angustata T. & G.	E. A.: Garner, N. C.	East. N. Am.	16
Calliandra inaequilatera Rusby	O. E. White: Huachi, Bolivia	Bolivia	16
Subfamily Caesalpinioideae			
Cercis occidentalis Torr.	Coimbra, Portugal	Sw. N. Am.	14
Gymnocladus dioica (L.) Koch	Blandy Exp. Farm	N. Am.	28
Gleditsia aquatica Marsh.	G.T. Ratcliffe: La. P. Tabor: Ga.	S. N. Am.	28
" *amorphoides* (Gris.) Taub.	Blandy Exp. Farm	Argentina	28
" *horrida* Willd.	" " "	China, Japan	28
" *sinensis* Lam.	" " "	China	28
" *heterophylla* Bge.	" " "	China	28
Subfamily Papilionatae			
Tribe Sophoreae			
Sophora tetraptera Ait.	Coimbra, Portugal	New Zealand	18
" *microphylla* Ait.	" "	Chile, Peru	18
" *secundiflora* (Ortega) Lag.	B. A. Krukoff: Mex.	Cent. Am., S. Am., Sw. N. Am.	18
Cladastris lutea (Michx.) Koch	E. A.: Charlottesville, Virginia	N. Am.	28
Ormosia panamensis Benth.	Canal Zone	Cent. Am.	16
" *Krugii* Urb.	L. F. Holdridge: Puerto Rico	West Indies	16
Tribe Podalyrieae			
Podalyria australis	Coimbra, Portugal	S. Africa	18
Baptisia leucantha T. & B.	O. E. White: Albany, Ga.	Se. N. Am.	18
Tribe Galegeae			
Caragana sp. (Rec'd. as *Boisseana*)	Coimbra, Portugal	Asia	16
Dalea alopecuroides Willd.	" "	E. N. Am.	14
" *occidentalis* Riley	H. S. Gentry: Mex.	C. Am.	14
Halimodendron argenteum (Lam.) D. C.	Blandy Exp. Farm	E. Asia	16
Sesbania macrocarpa Muhl.	O. E. White: Brunswick, Ga.	Se. N. Am.	12
Tribe Hedysareae			
Stylosanthes riparia Kearney	E. A.: Fort Valley, Va.	E. N. Am.	20
Zornia bracteata (Walt.) Gmel.	E. A.: Garner, N. C.	Se. N. Am.	20
Coronilla glauca L.	Coimbra, Portugal	S. Europe	24
Tribe Phaseoleae			
Rhynchosia erecta (Walt.) D. C.	E. A.: Keysville, Va.	E. N. Am.	22
Galactia volubilis (L.) Britton	J. T. Baldwin: N. C.	E. N. Am.	20
Apios tuberosa Moench	Blandy Exp. Farm	E. N. Am.	ca. 40

cladus, and *Gleditsia* contain both diploids and evolutionary polyploids, *Cercis* having $2n = 14$ chromosomes and the others, $2n = 28$.

In the subfamily Papilionatae, tribe Sophoreae, *Cladastris lutea* is probably the hardiest of the species studied. The polyploid number $2n = 28$ has only been found in one other species of the tribe, *Sophora japonica*, which is also of cool temperate distribution.

The tribes Galegeae and Hedysareae present an aneuploid range of chromosome numbers and considerable variation in chromosome structure. *Caragana* sp. from southern Asia and *Halimodendron argenteum* from the salt steppes of Asia are woody, while the *Dalea* and *Sesbania* species are herbaceous or facultatively woody. The Galegeae in general are taxonomically a more heterogenous group than the Sophoreae. The diverse chromosome numbers probably represent other evolutionary specializations than climatic selection.

Three herbaceous perennials in the Phaseoleae, *Rhynchosia*, *Galactia*, *Apios*, occupy similar areas in eastern North America. *R. erecta* and *G. volubilis* have $2n = 20$, *A. tuberosa*, $2n =$ ca. 40.

There is no evidence from the present data to support either positive or negative correlation of chromosome number with climatic distribution. Among the legumes considered here, both diploids and polyploids are found in tropical as well as temperate areas. White (1926, 1940) expressed the idea that in any plant population mutations for temperature tolerance may occur at random regardless of geographical distribution. Survival through hardiness seems to be more frequently a gene character which may find expression in either diploid or polyploid than a direct result of polyploidy.

There are approximately 6 species of trees and shrubs bearing polygamous flowers in *Gleditsia* (Burkhart, 1943). Geological evidence of the origin of the genus is meager, although Berry (1923) states that "a genus called *Gleditsiophyllum* found in both the Upper Cretaceous and the Eocene of North America is suggestively like the honey locust." Antiquity of origin is further supported by the presence of species of extreme morphological similarity in the temperate zones of North America and Asia as well as South America and Africa. Castronova (1945) has previously reported $2n = 28$ chromosomes in *G. amorphoides*, indigenous to Argentina. Atchison (1947a) reported $2n = 28$ in 33 collections of *G. triacanthos*, the North American honey locust; these represent a fair sampling of its range. In relation to other representatives of the Caesalpinioideae, i.e., *Cercis*, $2n = 14$, all present day Gleditsias which have been studied cytologically are polyploid. Little variation in chromosome size and structure can be noted among the species, though they have long been geographically separated. It may be assumed that chromosome variants including ancestral species with a lower number, if such have occurred, did not have sufficient survival value to withstand the climatic changes of the ages. The similar polyploid character and lack of specific morphological variation among the discontinuously distributed species of *Gleditsia* support its position as a relic genus of ancient origin and emphasize the chromosomal stability of the woody genera of the Leguminosae.

SUMMARY

Chromosome numbers are reported for 28 species of Leguminosae, including 9 species native to North Carolina. Comparisons of diploid and polyploid distributions show no correlation between temperature tolerance and polyploidy. The similarity of chromosome number and morphology among 6 discontinuously distributed species of *Gleditsia* supports the interpretation of the genus as a group of closely related relics of common origin.

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LENGTH OF APPLICATION OF THE EXCYSTMENT-INDUCING STIMULUS IN RELATION TO PERCENTAGE OF EXCYSTMENT IN TILLINA MAGNA[1]

By Robert Allen McIntyre, Jr.[2]

Department of Zoology, University of North Carolina
Chapel Hill, North Carolina

INTRODUCTION

It is well known that various types of environmental changes are effective in inducing the emergence of ciliated protozoa from their resting cysts. However, it is difficult to generalize with reference to the effectiveness of such changes in that a change which is effective for the cysts of one kind of ciliate may be ineffective for those of another. Dried cysts are excluded from consideration in the present study; all references to cysts therefore concern wet cysts; i.e., those immersed in a fluid medium. Plant extracts seem to be the most generally effective excystment-inducing substances. Thus, Barker and Taylor (1933) regularly excysted *Colpoda cucullus* with alfalfa infusion and yeast autolysate. Thimann and Barker (1934), noting that timothy hay infusion was highly effective for *Colpoda cucullus*, undertook an analysis of hay infusion in an effort to isolate and identify the effective substances. Haagen-Smit and Thimann (1938) continued the analysis and concluded that the effective substances were the plant acids and the sugars.

However, not all ciliate cysts require plant infusions or other types of organic substances for their excystment. Thus, Garnjobst (1928, 1937) could induce excystment in the hypotrichs *Euplotes taylori* and *Stylonethes sterkii* merely by diluting the original encystment medium with distilled water, and Beers (1945) found that distilled water alone was highly effective in excysting *Tillina magna*. Johnson and Evans (1940) distinguished two types of resting cysts in *Woodruffia metabolica*, "stable" cysts requiring organic substances and "unstable" cysts not requiring organic substances. Strickland and Haagen-Smit (1947, 1948) found that certain concentrations of potassium phosphate are effective excysting agents for *Colpoda duodenaria*.

The cysts of some ciliates appear to be very highly specialized with reference to their requirements for excystment. For example, Weyer (1930) found that bacterized gelatin solutions were the most effective agents in excysting *Gastrostyla steinii* after distilled water and inorganic media failed. Beers (1946) induced excystment in *Didinium nasutum* by using bacterized plant infusions after distilled water and other media failed.

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[2] Present address: Department of Biology, Coker College, Hartsville, S. C.

The cysts of *Tillina magna*, on the contrary, respond to a wide variety of environmental changes. Thus, Beers (1945) was able to induce excystment by means of distilled water, which had a high degree of excystment-inducing activity, and various plant infusions. A 0.05 per cent lettuce infusion was found to be the most effective excysting stimulus. In general, the results furnished by the studies of Beers (1945) and Bridgman (1948) indicate that the primary excystment-inducing factor in *Tillina* is of an osmotic nature, involving the entrance of water into the cell. The fact that cysts become active more rapidly in certain concentrations of lettuce and other plant infusions than in distilled water (Beers, 1945) indicates that the infusions contain specific excystment-inducing substances (the sugars and certain salts of the plant acids) which intensify the effects of the osmotic factor.

Although numbers of investigators have occupied themselves with the identification of some of the factors which are responsible for excystment, only Weyer seems to have given special consideration to the relationship which may exist between the length of the period of immersion in the excystment-inducing medium and the percentage of excystment. Weyer found that in *Gastrostyla steinii* the excystment-inducing medium must act continuously on the cysts throughout the entire process of differentiation and emergence. Otherwise, the process of differentiation and emergence ends, and the organisms return to the resting condition.

The relative ease and dependability with which the wet cysts of *Tillina magna* can be activated suggested the use of this ciliate in a further study of the effects of interrupting the excystment process. In considering this problem the following questions arise: What is the effect of transferring excysting specimens of *Tillina magna* from the excystment medium back to the original encystment medium? Is the process of excystment actually interrupted, as in *Gastrostyla*, with subsequent dedifferentiation and return to the encysted stage? Or is the process irreversible, once it is well under way? Is there a critical or threshold condition beyond which re-encystment is impossible, or can re-encystment be induced at any stage of the excystment process by discontinuing the application of the excysting stimulus? Thus, the present study concerns the relation of the length of application of the excysting stimulus to the subsequent events of the excystment process. Considered from the standpoint of experimental practicability, it concerns the relation between the length of application of the excysting stimulus and the percentage of individuals that excyst upon return to the original encystment medium.

MATERIAL AND METHODS

The tillinas used in this study were cultured in a 0.05 per cent lettuce infusion with the bacterium *Aerobacter aerogenes* used for food. The lettuce infusion was prepared by boiling 0.05 gm. of powdered dried lettuce in 100 cc. of Pyrex-distilled water for 5 minutes. This was then filtered and distributed to 30-cc. test tubes, each tube one-half to two-thirds full. Cotton plugs were inserted into each tube, and the lettuce infusion was then autoclaved. *Aerobacter* was cultured in Petri dishes on Difco nutrient agar.

In preparing *Tillina* cultures for the production of cysts, the following method was used: One cubic centimeter of 0.05 per cent lettuce infusion was put into a Columbia culture dish. Twenty-four active tillinas, all of the same clone, were put into the dish. Then with a small, sterile pipette 5–6 drops of a concentrated suspension of bacteria and lettuce infusion were added to the dish containing the active tillinas. This suspension was made by stirring 7–8 loops of bacteria into 1 cc. of lettuce infusion. Eight or ten of these cultures were usually begun at one time, and a stock culture was maintained to supply specimens for future use. The cultures were kept in a moist chamber with the temperature at 22–23°C.

Tillina magna multiplies rapidly as long as sufficient quantities of food are present. As the food supply became diminished in the cultures mentioned above, the animals began to swim about actively and very soon encysted. The ciliates usually began to encyst on the third day after the beginning of a culture, and by the end of the third day practically all the tillinas had encysted. At this time a great number of individuals had been formed, so that the number of cysts present was easily 350. The cysts used in the experiments were all of one clone. The cyst preparations were, then, completion cultures, prepared as needed. After all the animals in a dish had encysted, the cysts were allowed to remain for 4 more days during which time they reached a state of maturity or physiological stability. They were then ready for experimental use.

Attempts to culture *Tillina* on a strain of *Pseudomonas fluorescens* obtained from the Department of Bacteriology, School of Medicine, University of North Carolina, were unsuccessful, although Beers (1945) used a different strain of *Pseudomonas* with complete success. A strain of *Aerobacter aerogenes*, also obtained from the same source, was then tried and proved satisfactory. Kidder (1941) pointed out that *Tillina canalifera* is extremely selective in its choice of food, and in one experiment thrived on only one of 26 kinds of bacteria which were isolated from a wild culture of this ciliate. Apparently *T. magna* is equally selective, and this marked selectivity is probably the factor which accounts for the seeming rarity of *Tillina* in nature.

As already stated, Columbia culture dishes were used for obtaining the cyst preparations. There was a specific reason for using this type of dish. Boveri dishes were first employed in obtaining resting cysts of *Tillina*. However, when cysts were detached from their positions on the sides of the dish just beneath the surface of the encystment medium and allowed to fall to the bottom, it was found that in a short time excystment occurred in many of the cysts. It was conjectured, then, that *Tillina* cysts are so sensitive to environmental changes and excyst so readily that a change from the superficial layer of fluid to the lower layer of fluid was adequate to excyst them, different conditions, such as amount of oxygen, undoubtedly being encountered. The Columbia culture dishes were therefore used in place of the Boveri dishes, since it was assumed that conditions in the shallower dishes were more uniform.

A balanced salt medium (0.012 per cent Osterhout's solution) was first used in the preparation of cysts, but in all the experiments reported in this paper 0.05 per cent lettuce infusion was used. This medium was used rather than a bal-

anced salt medium, since it has not been conclusively demonstrated that inorganic salt media are entirely favorable for *Tillina*. Lettuce infusion, on the other hand, is entirely favorable in tonicity and reaction.

The tillinas were cultured for 7–10 days before using them in the preparation of the completion cultures. This practice resulted in the formation of satisfactory stable cysts. Unless the tillinas are allowed to pass through a number of divisions prior to the production of cysts, the resulting cysts exhibit spontaneous excystment and re-encystment and are therefore unsuited for experimental use. Consequently, it should be pointed out that it is very important to culture *Tillina* for 7–10 days (15–25 generations) before attempting to get cysts.

The excystment experiments were carried out in the following manner: With a clean needle cysts were detached from the sides of a dish in groups of 5–7. (When the ciliates encyst, they tend to do so in clumps.) A total of approximately 120 cysts were transferred in a sterile pipette to a Columbia culture dish containing 1 cc. of 0.05 per cent lettuce infusion. The cysts were here washed with a stream of the fluid from the pipette. In this fresh lettuce infusion the cysts were allowed to remain for 30 minutes, for example. They were next transferred to one of the concavities of a depression slide which contained 0.2 cc. of the old lettuce infusion (original encystment medium). Here they were thoroughly washed to remove any of the excystment medium which might have remained. Upon completion of this step the 120 cysts were transferred in groups of 40 to three depressions, each containing 0.2 cc. of the old lettuce infusion. At the end of 3 hours, i.e., counting from the time the cysts were put into the excystment medium, the depressions were examined under the binocular and a record made of the number excysted in each depression. At the end of the fourth hour a second record was made. At the temperature of the experiments the tillinas usually excysted during the last half of the second hour and the first half of the third hour. Hence, records made at the end of the third hour accounted for most of the cases of excystment. Individuals that lagged were usually accounted for in the 4-hour recording, preliminary experiments having shown that if the cysts are normal and possess the potentialities of excysting, they will most certainly have excysted by the end of the fourth hour. Therefore, no additional records were made after the fourth hour. Other groups of 120 cysts were used in the same manner as that described above, allowing them to remain in the excystment medium for 1 hour, 1.5 hours, and 2 hours.

It was the practice to test 1080 cysts in groups of 120 (from separate dishes) for each of the different exposure lengths. Therefore, data were obtained on a fairly large number of cysts for each length of exposure to the excysting stimulus. The following additional information should be given: The temperature at which the experiments were performed was 22–23°C., and the experimental dishes were kept in moist chambers. Initially sterile pipettes, glassware, and media were used. The cysts were transferred to the various dishes and depressions with a minimum amount of fluid. Experiments were terminated at the end of 4 hours, since it was felt that all the cysts which were going to excyst would have done so by this time.

For control purposes when running an experiment, cysts were subjected to the usual experimental manipulations, but with old lettuce infusion from a completion culture substituted for fresh lettuce infusion. These cysts showed no activity whatsoever. Thus, the mechanical operations of the experimental procedure are in themselves without effect on the cysts. As a means of testing the viability of the cysts in an experiment, some were transferred in groups of 20 to 0.2-cc. amounts of fresh 0.05 per cent lettuce infusion and left in it. These always excysted, yielding practically 100 per cent emergence.

Worthy of mention are some facts regarding the use of lettuce infusion as the excysting agent. The old lettuce infusion of the completion cultures is acted on by bacteria and contains waste products of bacterial and *Tillina* metabolism. The accumulation of this material in the medium and the accompanying depletion of the original nutrient materials evidently results in a condition of equilibrium between cysts and surrounding medium such that excystment does not occur spontaneously. Fresh, sterile 0.05 per cent lettuce infusion, not having been acted on by bacteria and containing none of the waste products of bacterial and *Tillina* metabolism, is therefore very different from the old lettuce infusion and is a highly effective excystment medium. The cysts, upon transfer to this medium, encounter a change of environment, with subsequent entrance of water into the protoplasts and eventual excystment.

For each exposure length the total percentage of cysts that excysted 3 hours and 4 hours after application of the excysting stimulus was calculated. For example, with reference to the cysts exposed 0.5 hour, the numbers of specimens excysted at the end of 3 hours in each of the three depressions of a group of 120 were added, the same being done for the other groups of 120. Then these sums—nine in all—were added, giving the total number excysted at the end of 3 hours. This number was converted to a percentage. In like manner, the percentage of excystment at the end of 4 hours was calculated. For the other exposure lengths—1 hour, 1.5 hours, and 2 hours—the same procedure was followed.

RESULTS OF EXPERIMENTS

The experimental results are summarized in accompanying Table 1.

A total of 1080 cysts were exposed to the excysting stimulus (0.05 per cent fresh lettuce infusion) for 0.5 hour and were then returned to the original encystment medium. Only 1.3 per cent of them excysted. There is no doubt that these cysts were affected slightly by the presence of the excysting stimulus, since they showed, as Table 1 indicates, moderate cyclosis at the time of removal from the excystment medium. Many of these cysts, as well as those used in other experiments, were examined under the compound microscope just before immersion in the excystment medium; very few of them showed cyclosis at this time. It is evident from these results that application of the excysting stimulus for only 0.5 hour, though adequate to induce cyclosis, is inadequate to cause any appreciable number to excyst when returned to the encystment medium.

A like number of cysts (1080) were exposed to the excysting stimulus for 1 hour (Table 1) before being returned to the original encystment medium.

These cysts, after 1 hour in fresh lettuce infusion, contained numerous vacuoles in the cytoplasm, showing that water had entered the cysts in appreciable quantities, and they were usually ciliated and rotating slowly in their membranes. Upon return to the encystment medium 83.5 per cent of them had excysted at the end of 3 hours, counting from the time when the excysting stimulus was first applied. At the end of the fourth hour an additional 1 per cent had excysted, giving a total of 84.5 per cent. In comparing these results with those involving a half-hour exposure, it is seen that a one-hour exposure produces an enormous increase in the percentage of excystment.

Then, a total of 1080 cysts were exposed 1.5 hours to the action of the excystment medium before being returned to the original encystment fluid. At the time of their return about half of the total number had escaped from the ectocyst

TABLE 1

Tillina magna. Relation between length of exposure to excystment-inducing stimulus and percentage of excystment upon return to original encystment medium. Temperature: 22–23°C.

TOTAL NUMBER OF CYSTS TESTED	LENGTH OF EXPOSURE TO EXCYSTING STIMULUS	CONDITION OF CYSTS WHEN REMOVED FROM EXCYSTMENT MEDIUM	EXCYSTED AT END OF 3 HOURS, COUNTING FROM BEGINNING	EXCYSTED AT END OF 4 HOURS, COUNTING FROM BEGINNING
	hours		*per cent*	*per cent*
1080	0.5	Cyclosis only.	1.3	1.3
1080	1	Numerous vacuoles; usually ciliated and rotating slowly; membranes intact.	83.5	84.5
1080	1.5	Some free in endocyst; others still vacuolated and rotating in unruptured membranes.	87.5	88.4
1080	2	Practically all now excysted.	98.5	98.5

and mesocyst and were imprisoned only in the endocyst, while the others were still vacuolated and rotating inside the unruptured membranes. Hence, none of them qualified as wholly excysted at the time of their return. However, 87.5 per cent of these cysts had excysted when the 3-hour readings were made, and 88.4 per cent an hour later.

Finally, 1080 cysts were exposed to the excystment medium for 2 hours. This length of exposure at 22–23°C. was adequate to induce the excystment of practically all of them, so that only a small fraction of the original 1080 could be returned to the encystment fluid. These continued their differentiation, with the result that 98.5 per cent of the cysts of this group excysted.

DISCUSSION

From the foregoing results it is seen that the cysts of *Tillina magna* differ from those of *Gastrostyla steinii* in their response to an interruption of the excystment-

inducing stimulus. Whereas the cysts of *Gastrostyla*, according to Weyer, require the continuous presence of the excystment medium in order to complete their emergence, those of *Tillina* continue the process of differentiation and emergence when they are removed from the excystment medium and returned to the old encystment medium. However, the excystment medium must be allowed to act long enough on the cysts of *Tillina* to set forcibly in motion the sequence of changes in the excystment process. Once these changes are well under way, the process of excystment is irreversible.

The induction of cyclosis by means of a half-hour immersion in the excystment medium does not suffice to stimulate the cysts to complete the excystment process; upon return to the encystment medium the process of excystment, of which cyclosis is the initial manifestation, ceases in practically all such cysts. If the immersion in the excystment medium is lengthened to an hour, nearly 85 per cent of the cysts become active upon return to the old medium. These cysts, after an hour's immersion, contain numerous vacuoles, showing that water has entered the cytoplasm in appreciable quantities; and they are usually rotating slowly in their membranes, as has been said, showing that the cilia are sufficiently developed to be weakly functional. This stage of excystment appears to constitute a critical or threshold condition. If this condition is not attained, the process of excystment is discontinued upon transfer to old medium. If this condition is actually attained, the process of excystment goes to completion, regardless of the subsequent presence of the excystment medium.

Since an immersion of 1 hour in the excystment medium at 22–23°C. is sufficient to induce the emergence of approximately 85 per cent of the cysts, it follows logically that an immersion of 1.5 hours should induce a still higher percentage of excystment. Thus, 88.4 per cent of such cysts emerged in the experiments. An immersion of 2 hours at the temperature of the experiments is in itself sufficiently long to induce the emergence of practically all the cysts, so that the return of the few still unexcysted specimens of this group to encystment medium was always without effect on their emergence.

SUMMARY

1. Resting cysts of *Tillina magna* were obtained in Columbia culture dishes containing 0.05 per cent lettuce infusion to which *Aerobacter aerogenes* had been added as food. These were completion cultures.

2. Cysts were transferred to the excystment medium (fresh 0.05 per cent lettuce infusion) and allowed to remain for 0.5 hour, 1 hour, 1.5 hours, or 2 hours before return to the encystment medium. A total of 1080 cysts were tested for each of the four exposure lengths, with the temperature at 22–23°C.

3. The groups of cysts which were exposed to excystment medium for 0.5 hour, 1 hour, and 1.5 hours, and then returned to encystment medium, showed the following percentages of excystment, respectively: 1.3 per cent, 84.5 per cent, and 88.4 per cent. Cysts that were left in the excystment medium for 2 hours had practically all excysted at the end of this time. The few which had not

excysted were returned to the encystment medium, with a resulting 98.5 per cent excystment for the total number of cysts tested.

4. Once the excystment changes are well under way in the cysts, the process is irreversible. The cysts do not require the continuous presence of the excystment medium in order for excystment to occur. The results indicate that the cysts must remain in the medium until they acquire numerous vacuoles and reach a condition of rotation within the membranes. In most cysts this condition is attained after about 1 hour of immersion in the excystment medium, though the time required is variable. If this condition is actually reached, the cysts will excyst, regardless of the presence or absence of the excysting stimulus.

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A NEW SPECIES OF ANCYLISTES ON A SACCODERM DESMID

By J. N. Couch

Department of Botany, University of North Carolina
Chapel Hill, North Carolina

Plates 6 and 7

The genus *Ancylistes*, now containing a small group of obligate parasites on desmids, was established by Pfitzer (1872) for a species which he found parasitizing *Closterium acerosum* at Bonn, Germany. This species, named *A. Closterii* by Pfitzer, has since been reported by several workers from Europe, Asia, and North America. Since Pfitzer's work, three additional species have been described. The first of these was described by Fritsch (1895) as *Ancylistes cladocerarum*, parasitic on rotifers, but has not been accepted by later workers as a valid species of *Ancylistes*. A year later Beck (1896) described a third species, *A. Pfeifferi*, based on material collected by Löfgren in Brazil. Beck's species was incompletely described from scanty material, and the vegetative stages were doubtless partly confused with *Myzocytium megastomum*. The discovery by Berdan (1938) of a species identical with or closely related to Beck's serves partly to validate his, and while she points out differences between the two in the size of the resting bodies and the number of protuberances on the wall she lets her parasite go under Beck's binomial *A. Pfeifferi*. A fourth species, *Ancylistes Miurii*, was described by Skvortzow (1925) in *Closterium* sp. from North Manchuria. There is some doubt as to whether this fungus belongs in *Ancylistes* or *Myzocytium*, as noted by Berdan, since the mycelium has the beaded appearance of *M. megastomum*.

At present there seem to be only two valid species of *Ancylistes*, *A. Closterii* and *A. Pfeifferi*. Both of these have been reported on species of the genus *Closterium*. It is unfortunate that not all observers have identified the species of host, indeed it seems that only Pfitzer and Berdan have done so. It is highly probable that not all of the parasites identified as *Ancylistes Closterii* belong to that species.

In Berdan's paper (1938), the most complete account of the genus so far published, she describes two species, tentatively identified as *A. Closterii* and *A. Pfeifferi*, and reports her remarkable discovery of conidia forcibly discharged into the air as in *Conidiobolus*, *Empusa*, etc., and on the basis of that discovery transfers the genus to the Entomophthorales.

As mentioned above, the authentic species of *Ancylistes* previously described have been found on species of *Closterium*, a genus of the placoderm desmids. The chief purposes of the present paper are to describe a species parasitic on a saccoderm desmid, *Netrium*, and to corroborate Berdan's discovery of conidia in *Ancylistes*.

Ancylistes Netrii n. sp.

Vegetative mycelium within the protoplast of host cell, consisting upon reaching mature size of a branched non-septate thread which usually starts its growth near the isthmus of the desmid in contact with the host nucleus and then elongates in opposite directions toward the ends of the desmid; at first non-segmented and 2.2–4.8 μ thick; when mature consisting of 3–6, usually 4, londitudinal branches which join in the isthmus of the desmid, becoming septate into numerous cells which are usually about 2–3 times as long as thick, measuring 8–15.5 × 15–30 μ; cytoplasm with numerous rounded granules and conspicuous round vacuoles; cells becoming conspicuously swollen just before and during germination. Reproduction by vegetative, asexual and sexual methods; all cells of thallus taking part in reproduction. In vegetative and asexual reproduction exit tubes are formed (one from each cell as a rule) and grow out at right angles or slightly diagonally from the parent cell and after coming in contact with the host wall swell distally to form a club-shaped structure about 2–4 μ thick at the base and 4–9 μ thick at the larger end; if submerged the exit tube, after emerging through the desmid wall, forms an external hypha 3–6.8 μ thick which grows through the water for some distance until it comes in contact with a new susceptible host cell; the protoplasm always in distal part of hypha and closed off from empty part by one or more cross walls. If the desmid is at the surface of the water the exit tubes form conidiophores, each unbranched and with a single apical spherical conidium; conidiophore stalk usually 25–100 μ long, sometimes longer, about 8 μ thick at its thickest point slightly below the conidium; conidia spherical, 16–25 μ thick, with a conical apiculus; forcibly discharged by the sudden outpushing of the apiculus; conidiophore with a distinct cone-shaped columella and quickly disintegrating after discharge of the conidia. Zygotes formed within the host, usually in a row in the center, between the several longitudinal hyphae and apparently by conjugation of two cells of opposite filaments, with the zygote in the conjugation tube; spherical or subspherical from pressure, 19–26 μ thick, the largest seen being 25 × 29.4 μ; wall about 2.5 μ thick, smooth; when mature with one large, slightly excentric shiny globule embedded in the cytoplasm.

In *Netrium digitus* on very moist earth and in shallow pools behind Dry Falls, near Highlands, N. C., July 17 and August 1, 1945; H. N. Couch, coll.

This species is easily distinguished from others by the club-shaped exit hyphae (fig. 17), the position of the zygotes in the center of the host cell and bounded laterally by the empty filaments of the parasite, the larger size of the conidia and zygotes, and finally by its occurrence in *Netrium*.

DEVELOPMENT OF ANCYLISTES NETRII

In this species, as in the two studied by Berdan, infection of new desmids may be by germ tubes which come directly from the cells of the intramatrical mycelium or by germ tubes which arise from discharged conidia. As shown by Berdan, conidia are formed only on desmids floating on or near the surface of the water. The conidiophores, on each of which is formed a single conidium, project about 20–50 μ into the air and hurl the conidia horizontally about two millimeters. Germ tubes from conidia or from the mycelium within other desmids approach an uninfected host and encircle it partly or completely, a phenomenon beautifully described by Pfitzer and others. These tubes growing

through the water in search of a host may reach a length of several hundred microns. As the tube elongates it becomes many times segmented, but all the compartments are empty of protoplasm except the distal one, as first shown by Pfitzer (1872).

When the end of the infecting hypha approaches the desmid wall, it enlarges to form an appressorium shaped like an adder's head. I have seen appressoria applied to various places on the host wall and it appears that penetration may be anywhere along the surface, although only a few penetration stages have been observed. The remains of the penetration tube are shown in fig. 9. Soon after the parasite enters it appears to be carried to the host nucleus, where it elongates to form a short tube in contact with this organ (fig. 10). Dangeard (1886) describes the young hyphae as without a definite wall in *Ancylistes Closterii*, and the same seems to be true in the present species. Dangeard also makes the interesting observation that after infection the desmid continues to move slowly by the usual tumbling movements and thus helps to bring about the distribution of the parasite.

From its central position near the nucleus the hypha branches and grows in opposite directions toward the ends of the desmid, usually with one hyphal branch in each groove between the longitudinal plates of the chloroplast (figs. 11, 12). Not infrequently when a hypha reaches the end of the desmid it grows around the end of the chloroplast and comes back on the opposite side (fig. 13), as indicated by Berdan. The mature hyphae are over twice as thick as the young threads. It appears that the increase in thickness occurs mostly after the growth in length has ceased. The septations also appear after the hypha has attained its full length. These are not formed simultaneously but progressively from one region to another (fig. 13). Material mounted in lactophenol with dilute coton blue shows that each segment contains several nuclei as do the conidia, gametangia, and zygotes, thus corroborating Dangeard's (1906) observations. The mature mycelium consists of about 30–50 multi-nucleated cells, each of which normally functions in reproduction in one of three ways: a cell may give rise to an exit tube which penetrates the desmid wall to form an external infecting hypha; it may, after forming an exit hypha, give rise to a conidiophore; or a cell may form a gametangium which fuses with another to form a zygospore or without fusion a cell may form an azygospore.

Just before the exit tubes arise, the cells swell considerably so that the hyphae appear constricted at the septa. The exit tube always rises at the end of a cell growing straight out or slightly diagonally toward the host wall (figs. 5, 17). It is a rather narrow tube and at first is of the same diameter throughout its length (fig. 14).

The cell wall of *Netrium* consists of a homogeneous inner layer of cellulose and an outer layer of pectose according to Lütkemüller (1902, from Smith, 1933). Viewed under the water immersion there usually appear to be an outer, thinner, hyaline layer and a much thicker, inner, slightly yellowish layer (fig. 18). This thicker layer seems at times to be bounded internally by a third, thinner, hyaline layer. The observations presented below seem to indicate the presence of a third inner layer.

When the exit tube touches the wall of the desmid it penetrates the inner layer of the host wall and then enlarges to form a club-shaped structure (figs. 14–16). As the end of the hypha enlarges a thin, inner part of the wall is separated off from the thick yellowish part, since it separates more easily than it tears (fig. 18). This part that separates off seems to be a true third layer. The inner wall is probably penetrated by enzymatic action of the hyphal tip, while the thicker middle and outer parts, in which valvular cracks may sometimes be observed, are apparently cracked by force. One of the best lines of evidence that mechanical force is exerted against the outer wall and that the inner wall counterbalances this force is that when the exit hypha is empty or is slightly plasmolyzed the wall of its enlarged portion, between the outer and inner walls, buckles considerably (figs. 18, 20). Similar behavior was shown by the exit hyphae of *Ancylistes Closterii*, as shown by Berdan in her fig. 4. She considered this inner layer (labelled M in her figure) as the plasma membrane but it probably was the inner wall layer. In *Ancylistes Pfeifferi* penetration by the exit tube, judging from Berdan's figs. 12 and 13, is effected in a different manner than in *A. Netrii* and *A. Closterii*. This may be due to differences in the wall structure of the host. The type of penetration shown by the latter two, in which the host actually assists the parasite in puncturing the host wall, is unreported in previous literature (see Gäumann, 1945) and should be more thoroughly studied in this genus. The germ tubes of *Ancylistes* are large and penetration can easily be observed in the living condition.

As stated above, the exit tube may, when it reaches the outside of the desmid, grow into a hypha which infects directly some other desmid. If the tube is close to the surface of the water, it may form a conidiophore (figs. 1, 17, 19). Each cell of the mycelium may give rise to a conidiophore and thus several dozen may arise from one desmid. The conidiophores are formed and forcibly discharged in this species just as in *A. Closterii* and *A. Pfeifferi*, as described by Berdan.

My observations on the conjugation of the gametangia and the formation of the zygote are inconclusive, for although I had an abundance of living material in all stages I was unable to follow the development of the zygote. My observations were made from material preserved in lactophenol and stained with coton blue. The zygotes are formed mostly by scalariform conjugation and mature in what appears to be a conjugation tube (figs. 21, 22). They are almost always in one or two irregular longitudinal rows in the center of the desmid, surrounded by the longitudinal hyphae, and hence it is quite difficult to follow the stages in their development (figs. 7, 8, 22). The germination of the zygote has not been seen.

SUMMARY

A new species of *Ancylistes* is described as *A. Netrii*. This is the first time this genus has been reported on a saccoderm desmid. Conidia are reported in this species, thus confirming Berdan's earlier discovery of conidia in two other species. The exit tube of *A. Netrii*, in making its way through the host wall,

first penetrates the inner wall layer. The end of the tube then swells, separating the inner layer from the outer and the tension set up by the stretching of the inner layer assists the fungus in pushing through the outer layer. This method of host wall penetration, found also in *A. Closterii*, seems to be unreported for any other genus.

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EXPLANATION OF PLATES 6 AND 7

Ancylistes Netrii

FIG. 1. Several conidiophores projecting from desmid up to surface of water. Some have already shot their conidia and the columellae are still visible; others have spherical conidia attached. × 270.

FIG. 2. Short conidiophore (lower part of photograph) which has just shot its conidium, and a long one with indistinct stalk and conidium still attached. This has been flooded with water and the vacuole destroyed, so the conidium will not be discharged. The irregular granular body near center is perhaps an amoeba. × 625.

FIG. 3. Mycelium mature and becoming septate but no reproduction yet. Dark material in center is disorganized chloroplasts which were still green when the photograph was made. × 270.

FIG. 4. Slightly later stage than above. × 270.

FIG. 5. Exit hyphae about to emerge through desmid wall to form conidiophores. Note how mycelium of parasite has been pushed to side of desmid. × 270.

FIG. 6. Two exit tubes which have penetrated through wall. Note host wall split. Plasma membrane is close to large parasite cells. For further explanation see text. × 625.

FIGS. 7, 8. Zygotes almost completely covered by the disorganized plastids and by the empty hyphae of parasite. In fig. 8 five zygotes can be made out indistinctly. × 385.

FIG. 9. Showing infection tube passing through host wall. × 1400.

FIG. 10. Earliest stage of parasite recognized. Hypha (h) without a cell wall is in contact with host nucleus (h. n.). × 368.

FIGS. 11, 12. Hyphae elongating. New branches forming at isthmus of desmid. × 368.

FIG. 13. Septa forming progressively. × 368.

FIGS. 14–16. Stages in exit hyphae penetrating host wall to exterior. p.m. plasma membrane; i. w. and o. w., inner and outer parts of host wall, respectively. For further explanation see text. × 1000.

FIG. 17. Desmid containing mycelium forming conidiophores, one from each hyphal segment. Such a desmid is close to the surface of the water and usually in a horizontal position. × 290.

FIG. 18. Exit hypha buckled after pushing through outer part of host wall and forming conidiophore. × 1400.

FIG. 19. Conidiophores. On left, with conidium attached; on right just after conidium has been shot from stalk. *A*, apiculus; *C*, columella; *V*, vacuole. Diagrammatic. × 290.

FIG. 20. Mycelium, every segment of which has formed a conidiophore. Only 7 exit tubes are shown. Cross-hatched material in center represents dead remains of chloroplasts. × 368.

FIG. 21. Young zygote apparently formed in conjugation tube. × 635.

FIG. 22. Two zygotes nearly mature, the lower with large excentric fat body. × 635.

PLATE 6

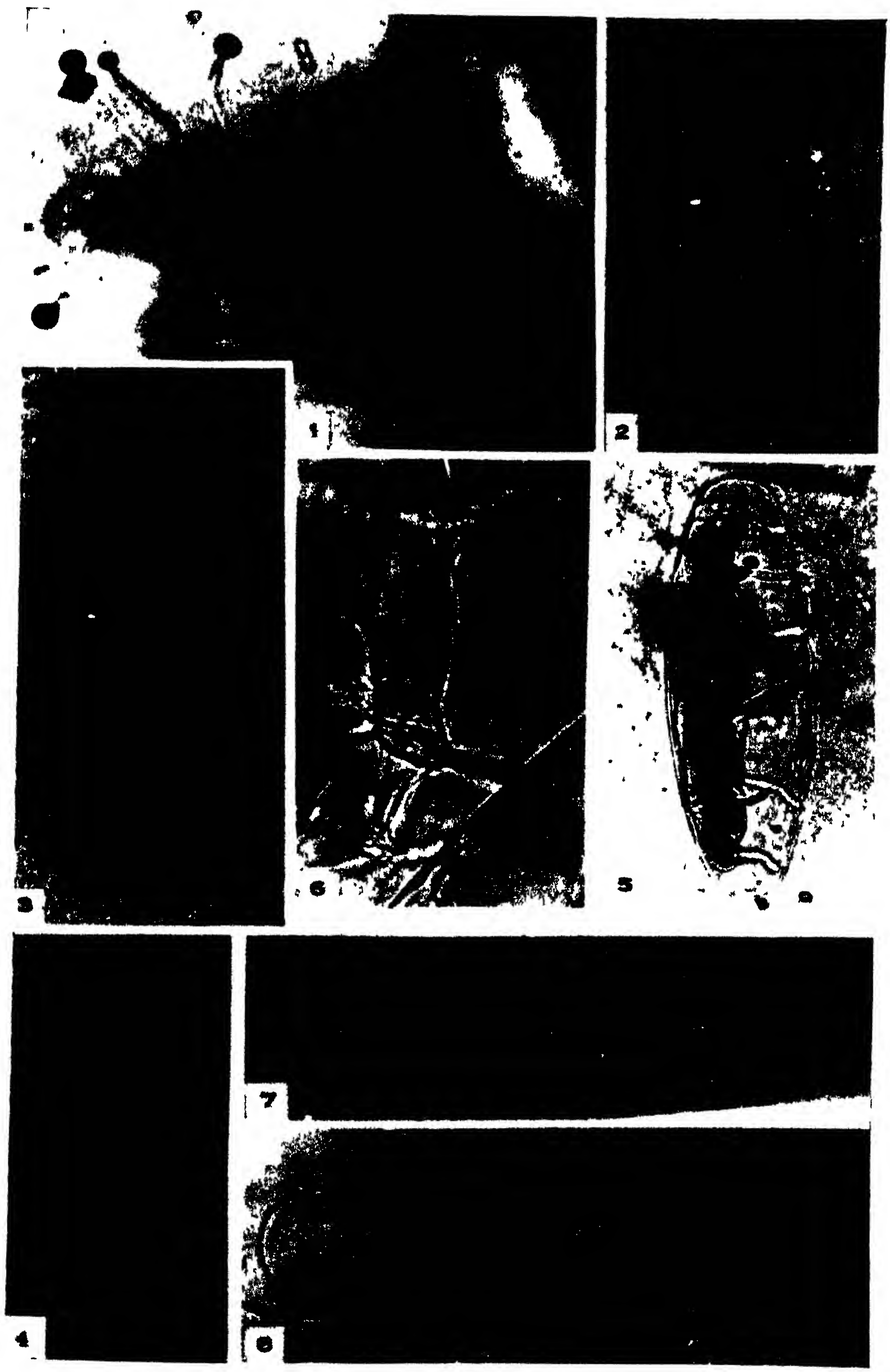
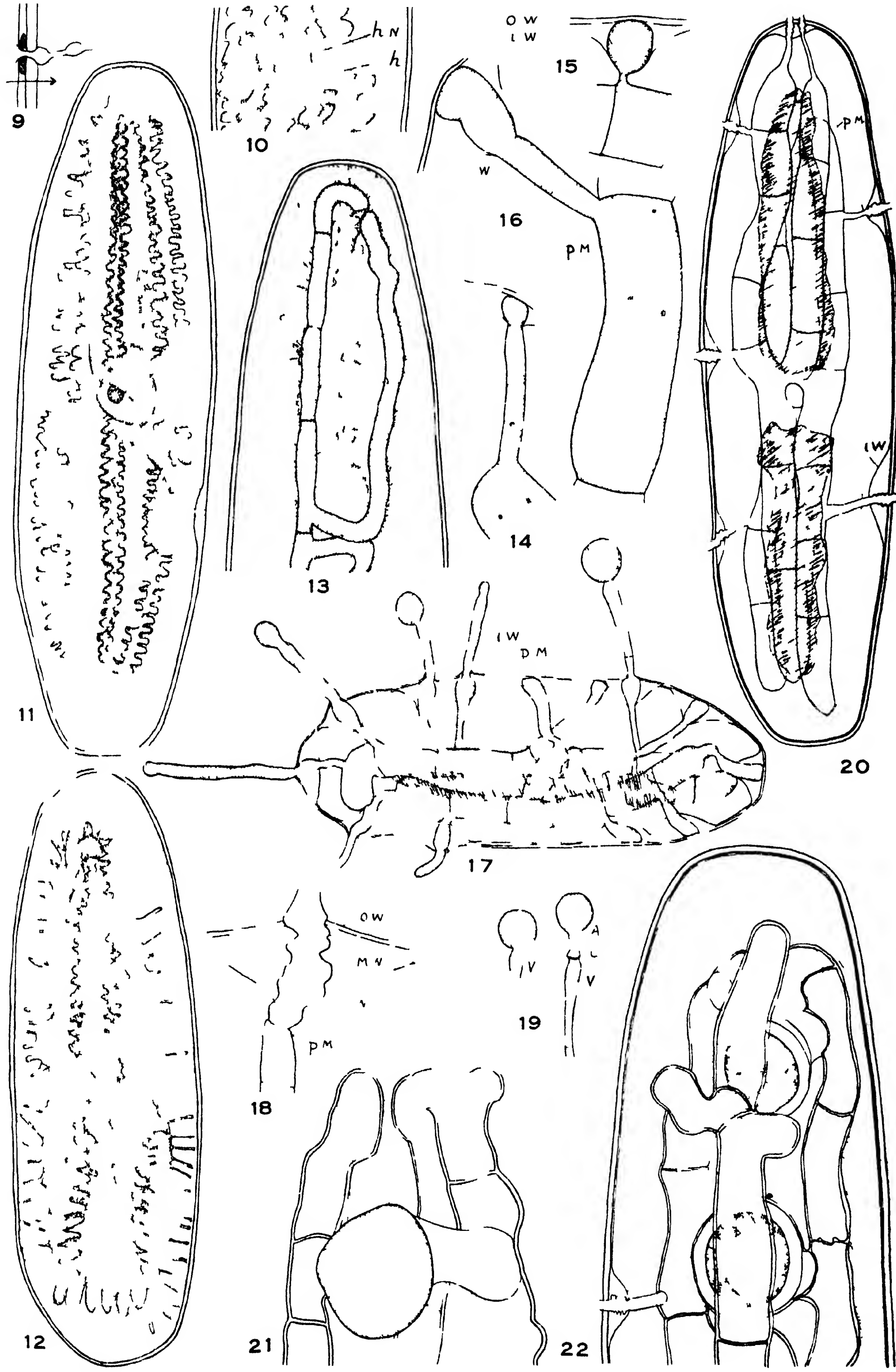


PLATE 7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A CYTOTAXONOMIC STUDY OF THE SARRACENIACEAE OF NORTH AMERICA*

By Clyde Ritchie Bell

Department of Botany, University of North Carolina
Chapel Hill, North Carolina

Plates 8–14

INTRODUCTION

Despite almost universal interest, both popular and scientific, in insectivorous plants the many volumes of previous work on the various genera and species do not include a thorough cytological study of the members of the Sarraceniaceae. The taxonomy, morphology, distribution, and insectivorous nature of these plants had been dealt with by Macfarlane (1908), Harper (1918), Wherry (1933) (1935), Lloyd (1942), and others; but it was only recently that Tjio (1948) working with "tropical plants" made a chromosome count as such for a plant in the genus *Sarracenia*.[1] This work with only two horticultural hybrids involved no specific or interspecific characteristics, but reported 2n=26 for the plants investigated. The present investigation demonstrates twenty-six to be the 2n number for all species of the genus *Sarracenia*. Two previous papers, Shreve (1906) and Nichols (1908), reported twelve as the reduced number of chromosomes in three species of *Sarracenia*. These papers were not primarily concerned with chromosome number, but reported it as an observation made in the course of other studies on these plants, and may now be discounted.

GENERAL METHODS

The results and interpretations set forth in this paper were arrived at by the following several lines of investigation pursued more or less simultaneously in order that the various findings along different lines of research could be properly evaluated and compared.

A thorough review of all pertinent literature and herbarium material was made, and the type locality for each species of *Sarracenia* was visited. Collections of living plants of each species of *Sarracenia* studied were made from the type locality if possible and from other typical areas. These plants (including some of *Chrysamphora* sent from California) are growing in the greenhouse for further study and experiment. The cytological approach had not previously been applied to the two genera. Results of this approach show the two genera to be distinct and the species of *Sarracenia* to be closely related. (See section on Cy-

* This paper was condensed from a thesis presented to the faculty of the University of North Carolina in partial fulfillment of the requirements for degree of Master of Arts in the Department of Botany.

[1] Since this paper was completed for publication a chromosome count for the six Florida species of *Sarracenia* was published by Hecht in Bull. Torrey Bot. Club 76: 7–9, 1949.

tological Methods and Results.) Because of the monotypic status of *Chrysamphora* extensive comparative field studies in this genus were not considered necessary.

GEOGRAPHICAL DISTRIBUTION

Although the specific range limits are given for each species treated in this paper, a brief summary of the general range of all plants under consideration may be of some value.

The western representative of the pitcher plants is *Chrysamphora* and is found in a limited range of northern California and extreme southwest Oregon.

Sarracenia purpurea is found more or less over the entire eastern part of North America from Canada to Florida, but the other species in the genus *Sarracenia* are found only in the southeastern part of the United States. Therefore since only the southeastern states have more than one species of *Sarracenia* they are listed here. The approximate extent and density of any specific population in relation to other members of the genus is indicated by subordinate position in the list. The number of different natural hybrids found is given for each state, but they are not listed here. See section on Natural Hybrids.

VIRGINIA, two species: *S. flava*, *S. purpurea*.

NORTH CAROLINA, four species, one form: *S. flava*, *S. purpurea*, *S. rubra*, *S. minor*, *S. rubra* forma *jonesii*; plus three hybrids.

SOUTH CAROLINA, four species, one form: *S. flava*, *S. minor*, *S. purpurea*, *S. rubra*, *S. rubra* forma *jonesii*; plus three hybrids.

GEORGIA, seven species, one form: *S. flava*, *S. minor*, *S. psittacina*, *S. Drummondii*, *S. rubra*, *S. purpurea*, *S. oreophila*, *S. rubra* forma *jonesii*.; plus three hybrids.

ALABAMA, seven species, one form: *S. Drummondii*, *S. Sledgei*, *S. purpurea*, *S. flava*, *S. psittacina*, *S. rubra*, *S. rubra* forma *jonesii*, *S. oreophila*; plus five hybrids.

FLORIDA, six species, one form: *S. minor*, *S. psittacina*, *S. Drummondii*, *S. flava*, *S. purpurea*, *S. rubra* forma *jonesii*, *S. rubra*; plus three hybrids.

MISSISSIPPI, five species, one form (all scarce and limited in range): *S. Sledgei*, *S. psittacina*, *S. Drummondii*, *S. purpurea*, *S. rubra* forma *jonesii*, *S. rubra*.

LOUISIANA, three species: *S. Sledgei*, *S. psittacina*, *S. purpurea*.

TEXAS, one species (scarce and of limited range): *S. Sledgei*.

CYTOLOGICAL METHODS AND RESULTS

All anther material used for cytological study was fixed in Craf or Carnoy's solution, stored in 70% alcohol, and smeared in aceto-orcein. No successful anther smears of *Chrysamphora* were made since all the buds of this plant sent from California were too far advanced. Root tips were also fixed in Craf or Carnoy's solution, embedded, sectioned (12μ), and stained with crystal violet.

Root tip smears were rarely successful due in part to the many cell inclusions which made observation difficult and to the small percentage of dividing cells,

even in "growing" root tips. Serial sections of root tips rarely showed much meristematic activity in any region, the roots growing very slowly (or not at all unless water were withheld from the plants for a week and then given sparingly).

All material used in the final preparation of the cytological section of this paper was taken from plants collected (except *Chrysamphora californica*, which was purchased from a collector in California) by the writer in the spring and summer of 1948. Thirty to sixty plants were collected of each species of *Sarracenia*; collections of two to ten plants were made at various stations within the general range of the species to assure the material as typical. The plants are very hardy and will stand rough treatment in transplanting if not allowed to dry out. All plants collected were planted in beds of peat in the greenhouse and marked as to collection number. Any collection number in the 2-series indicates living material, not pressed specimens. Plants were usually collected only in early bud to insure having enough material for the anther smears. Supplementary collections of buds from plants that could be positively identified in the field were often made. These buds, ranging in size from 0.6 cm. to 1.1 cm. were put in marked vials of Carnoy's solution and later stored in 70% alcohol.

A more or less definite bud size for each species was usually found which would give the desired meiotic stages. The average size of useful buds was about 0.7 cm., varying of course with the size of the plant of the species concerned; this size is reached in a week to ten days after the bud first becomes visible.

Bud collections, and thus the anther smears, were kept on an individual plant basis. The root tips, however, were collected and examined on a species basis. The mixing of root tip material from different plants within a species and from plants from different collection areas further assured "average" or "typical" cytological observations. Any irregularities would, of course, have necessitated making further collections and observations on an individual plant basis. No such collections were found necessary.

A reduced number of thirteen chromosomes was obtained for each species of *Sarracenia* (Plate 10). An unreduced number of twenty-six chromosomes, from excellent root tip material, was observed to be constant in all *Sarracenia* species (Plates 8 and 9).

The constant chromosome number throughout the genus *Sarracenia* and the lack of differentiation in regard to chromosome morphology of the various species were rather to be expected, however, in view of the ease with which the various species cross in nature or are crossed by horticulturists.

The chromosomes of all members of the genus *Sarracenia* ranged from 2.0 to 4.0 microns in length. The average chromosome length of any given genome, however, is only about 2.8 microns, since most of the chromosomes tend to be nearer the smaller extreme in length.

Slight average differences between species of *Sarracenia* will be noted, but the degree of variation is too small to be of any taxonomic value, and such average chromosomal variations as do exist between species may well be of lesser magnitude than the average variations between the genomes within a species. To emphasize the point it will be noted that the average chromosome length for *S.*

rubra is 2.75 microns while that of *S. minor* (the opposite extreme) is 2.86 microns —a difference of only 0.11 microns. Such a difference may be termed typical as far as interspecific chromosome morphology is concerned in this genus, and such differences would probably be increased or decreased by the interpretation of another worker; therefore even these small differences could not be considered constant. This average difference is exceeded somewhat in the genomes of the above mentioned two species as pictured (Plate 9, figs. 5–6). The chromosomes pictured for *S. minor* are larger than usual for this species and those pictured for *S. rubra* represent the smallest chromosomes observed within the genus *Sarracenia.* The exceedingly small size of the *S. rubra* chromosomes in this genome is accentuated by the compactness of their arrangement and by the larger, more widely spaced chromosomes of *S. minor* just below them.

The only constant character in regard to the chromosomes for any given species of *Sarracenia* is the number, the 2n number being twenty-six throughout the genus *Sarracenia.* A single chromosome with a large satellite was observed in every species of *Sarracenia* except *S. rubra.* Since this characteristic was not always observed in each species in which it was known to occur it is probable, in view of other close interspecific morphological similarities, that the genome of *S. rubra* also has such a chromosome. An unreduced number of thirty chromosomes was found in the other North American genus of pitcher plant, the monotypic *Chrysamphora.* The chromosomes of *Chrysamphora californica,* however, vary not only in number from the species of *Sarracenia,* but also in size, averaging only *ca.* 1.5 microns in length (Plate 12). Four chromosomes per genome in the California pitcher plant were slightly longer than the others. Two of these were usually observed to have a pair of large satellites each; otherwise there were no distinctive characteristics observed in this genus.

The previously mentioned numerical difference between the two genera gives further proof (if any be needed) as to their taxonomic and morphologic individuality. Further conclusions, as to the relationship of the genera, based on the two chromosome numbers would be based only on theory, and will not be attempted.

CONSIDERATIONS OF SPECIATION

It must be noted that assignment of a given individual or group of individuals to any specific or subspecific taxonomic category will depend upon the individual taxonomist's interpretation of the word "distinct" as it relates to any given difference or differences used as a basis for taxonomy.

The over-all shape or form of the pitchered leaves is generally a constant morphological characteristic, and as such is the most useful single feature used by taxonomists in species delimitation within the genus *Sarracenia.* Leaf coloration, except where constant and peculiar to a single species (as the white in *S. Drummondii* and the clear yellow-green in *S. purpurea* forma *heterophylla*), is of no taxonomic value since leaf coloration within any one species often shows most of the yellow-green-red combinations possible within this genus. The number of ensiform leaves produced is a factor of importance only in the single

extreme case of *S. oreophila*; no other related species produces these leaves in such abundance.

Flower color alone is of little value since all species normally have flowers of either one or the other of the two possible colors—red or yellow. Flower scent is a distinctive feature in two species of *Sarracenia*. *S. rubra* has a sweet scent while *S. flava* has a very singular musty odor. Petal shape varies from species to species within the genus, but it also varies considerably from plant to plant within a species. Only the extremely obovate petal shape usually found in *S. rubra* is therefore of any use to the taxonomist. This also applies to the extreme recurved condition of the sepals of *S. rubra*, the other species showing an intermediate degree of recurving, or none at all.

Size is of no value *per se* in species delimitation in this genus. Various ecological factors result in mature plants of many sizes within any given species. The extreme cases of this are shown by *S. minor* and *S. flava*, but less striking differences in size appear in all other species of *Sarracenia*. Size, therefore, is not a constant and cannot be used as a basis for taxonomic differentiation.

Some of the less obvious or microscopic morphological features found within this genus, such as pubescence or number and location of nectar glands, are not of any taxonomic value alone and may or may not be of such value when used with one or more of the grosser features of the plant.

Speciation, then, rarely depends on a single major or minor morphological characteristic, but on a group or series of characteristics considered together; and such a group must in turn be considered in relation to other such groups found within the genus.

When plants are so viewed, one is able to see not only their differences, but what is more important, their relationships. Thus in the genus *Sarracenia* leaf shape not only aids in the proper classification of the species, but shows that there are related groups of species within the genus. It will be noted as once that *S. oreophila*, *S. flava*, and *S. Sledgei* are a closely related group. *S. Drummondii*, *S. rubra*, and perhaps *S. minor* appear to be more distantly related to this same group. *S. psittacina* and *S. purpurea* may belong to another single group within the genus; but if so, they occupy rather separated positions.

From morphological comparisons and other data the most primitive or oldest member of a genus (or a larger taxonomic unit) may be determined. Since the pitcher plants are an evolved form and since there are so few members in the genus and these occupy such a comparatively limited range, a determination of the type nearest the original or parent type is difficult. *S. purpurea* is the most widespread, and therefore might be thought of as the oldest plant type in the genus. All seedlings of any *Sarracenia* have leaves the first year that are very similar to the mature leaves of *S. minor* which Macfarlane (1908) considers the most primitive. Wherry (1933) states that the yellow-green color and a range in an old geologic area indicate *S. oreophila* to be the oldest form of *Sarracenia*.

There are probably other arguments for and against each of the above theories, any one of which could be correct, but cannot be demonstrated satisfactorily at this time.

TAXONOMIC TREATMENT

The various herbaria used in the preparation of the following material are designated by the following abbreviations: NY, New York Botanical Garden; PENN, University of Pennsylvania; PH, Academy of Natural Science; US, United States National Herbarium; DUKE, Duke University Herbarium; CNC, University of North Carolina Herbarium.

KEY TO THE GENERA OF NORTH AMERICAN PITCHER PLANTS

Hood of ascidiform leaves appendaged; scape bracted, style radiate, petals bronze yellow ***Chrysamphora*** **(monotypic)**
Hood of ascidiform leaves not as above, scape naked, style expanded........*Sarracenia*

KEY TO THE SPECIES OF SARRACENIA

Pitchered leaves erect
  Pitcher orifice more or less open
    Hood large, margins reflexed
      Hood yellow-green with slight to profuse red venation or occasionally solid red, petals yellow
        Ensiform leaves abundant, petals greenish yellow............1. *S. oreophila*
        Ensiform leaves sparse or lacking
          Hood margin strongly reflexed, petals clear yellow; scent musty....2. *S. flava*
          Hood margin only slightly reflexed, petals cream yellow; scent none..3. *S. Sledgei*
      Hood white, green and red-reticulate, margins undulate, petals maroon 4. *S. Drummondii*
    Hood small, margins not reflexed, petals red, often extremely obovate, sepals strongly recurved..5. *S. rubra*
  Pitcher orifice covered by hood, petals yellow...........................6. *S. minor*
Pitchers decumbent, flowers red or rarely yellow
  Orifice lateral, hood closed...................................7. *S. psittacina*
  Orifice terminal, hood open....................................8. *S. purpurea*

Chrysamphora californica (Torrey) Greene, Pittonia **2**: 191. 1891.
Darlingtonia californica Torr. Smiths. Contrib. **6**, art. 4: 5. 1854.

Leaves hollow, expanded upward toward inflated hood, green, more or less suffused with red-purple; hood containing many translucent blotches; orifice somewhat lateral or under protruding proximal expansion of hood, protected in a manner by two elongate, leaf-like appendages. Scape solitary, bracted, about as long as leaves. Sepals oblong, 3–5 cm. long, yellow-green on outer surface, rusty purple inside; petals 2–3 cm. long, ovate-lanceolate, narrowed toward ends, reddish-purple to bronze yellow; style short, five-lobed, radiate. Loculicidal capsule 5-valved.

Type locality: Headwaters of the Sacramento River, northern California, near Mount Shasta, growing in marshes.

Range: Bogs, from sea level at Lane County in southwest Oregon to 8000 feet in Placer Co., California.

Representative specimens: OREGON. Florence, Lane Co. *Wherry* (PH 676444); Bandon, Coos Co. *Thompson* (PH 663801); Selma, Josephine Co. *Gould 811* (NY). CALIFORNIA. Oregon Mtn., Siskiyou Co. *Wherry* (PENN); Plumas Co. *Lemmon* (PENN).

The only easily recognized feature the California pitcher plant has in common with its eastern relative is the singular form of the insectivorous leaves, and even here the appendaged hood of *Chrysamphora* differs from the simpler hood of *Sarracenia*. The flowers of the former are entirely different in form from the latter. The recognition of two genera would seem warranted without consideration of the difference in range or the difference in chromosome number.

The flowers of *Chrysamphora* (which blooms from April to July in its native habitat) are extremely long-lasting. Two plants received in bloom from California remained in bloom for well over a month when planted in the greenhouse. The leaves of *Chrysamphora*, except for the two appendages, look very much like the leaves of *S. psittacina*, but grow erect and to a much larger size. The internodes of *Chrysamphora* are somewhat larger than those of *Sarracenia*. Thus the leaves are less crowded on the rhizome and appear as a short row rather than as a cluster or basal rosette.

The western species of pitcher plant has the same basic ecological requirements as those of the southeastern species—high soil acidity and moist habitat. It grows, however, through a greater altitudinal range than any of the eastern members of this family.

No record can be found of any attempted cross between *Chrysamphora* and *Sarracenia* sp.

1. **Sarracenia oreophila** (Kearney) Wherry, Bartonia **15**: 8. 1933.
   - *S. flava Catesbaei* Mohr, Bull. Torr. Bot. Club **24**: 23. 1897. Type loc. Ala., DeKalb Co., Lookout Mtn., bank of Little River, about 1700 feet.
   - *S. flava* var. *oreophila* Kearney, nomen nudum, Science **12**: 837. 1900. Type loc. Lookout Mtn., especially near its southwest end in Alabama.
   - *S. Catesbaei* Elliott, of Mohr (*not* Elliott), Plant Life of Alabama, p. 531. 1901.
   - *S. flava* in part, certain authors (as to localities).

Summer leaves green, erect, ascidiform 3–7 dm. tall, well developed at flowering time, hood suberect, rounded, apiculate, moderately constricted at base, slightly if at all revolute; winter leaves flat, ensiform, recurved, numerous, 1–2 dm. long in basal rosette. Scape about as high as summer leaves. Sepals green, 3–5 cm. long, widest near middle, rounded at apex; petals greenish-yellow, narrowly fiddle-shaped, 4–5.5 cm. long, widest at expanded basal portion; style disk 3–6 cm. in diameter, pubescent. Mature capsule 0.75–2 cm. in diameter.

Type locality: Alabama. DeKalb Co., Lookout Mtn., bank of Little River near DeSoto Falls.

Range: Rare along sandy stream banks in the mountains of northeastern Alabama and extreme west central Georgia. Also reported by Wherry from Elmore Co., Alabama.

Representative specimens: ALABAMA. Flat Rock, Jackson Co. *Wherry* (PENN); Valley Head, De Kalb Co. (US 980565); Little River, Mentone, Cherokee Co. *Bell 510* (CNC); Center, Cherokee Co. *Harper* (US).

S. oreophila in its small, more or less mountainous, inland range blooms about

the middle of May. The plants in Elmore County, Alabama, probably bloom somewhat earlier; but no plants were observed or collected in that area despite extensive searching during March, 1948.

The flowers of *S. oreophila* are similar to those of *S. flava*, to which it is obviously closely related, but the petals are narrower; and although Wherry says in his description of the species that the flowers have a faint musty scent, those collected along the east bank of the Little River below Mentone, Alabama, for this study had no noticeable odor, musty or otherwise.

Several workers prior to Wherry had recognized the plants of *Sarracenia* collected in northeastern Alabama as being different from "typical" *S. flava* and had made various attempts at naming them. Mohr (1897) first named these plants *S. flava Catesbaei* in his "Notes on some undescribed and little known plants of the Alabama Flora," believing them to be identical with *S. Catesbaei* Elliott (1824). Four years later in his "Plant Life of Alabama" Mohr raised these plants to specific rank, as *S. Catesbaei* Elliott. Elliott's *S. Catesbaei* described in 1824 from specimens collected "along the margins of rivulets amidst the high sand hills of Chesterfield district in S. C." by Macbride were considered by Croom, who saw Elliott's specimen, to be *S. flava* and by Macfarlane who annotated the specimen to be a natural hybrid between *S. flava* and *S. purpurea*. Macfarlane's evaluation of *S. Catesbaei* Elliott is doubtless correct and such hybrids bear that name at the present time. The inapplicability of the name *Catesbaei* to the plants of N.E. Alabama collected by Mohr is obvious. Meantime Kearney (1900) apparently unaware of Mohr's plants named plants observed at the locality of Mohr's previous collections *S. flava* var. *oreophila*, but did not describe them. Macfarlane (1908) does not recognize the plant, but cites a collection of *S. flava* from Valley Head, Ala., and notes Mohr's name of *S. Catesbaei* in connection with it. Harper (1918) recognized Kearney's name, *S. flava* var. *oreophila*; finally, Wherry (1933), recognizing the distinctiveness of the plant, has supplied a complete description of the plant and named it *S. oreophila*.

The name *Catesbaei* has thus been removed from specific rank in the genus *Sarracenia*. This is indeed fortunate, for many of the early botanists seem to have applied the name, along with very sketchy if not inaccurate descriptions, to several different new, odd, or otherwise unidentified plants of *Sarracenia*, and any present use of the name in a specific capacity would only add to the taxonomic confusion surrounding it.

Aside from the lack of scent, which is so strong in *S. flava*, *S. oreophila* also differs from that species in having many more flat winter leaves, many of which are strongly recurved. The ranges of the two species are very distinct and the habitats differ. *S. oreophila*, instead of being found in bogs, usually occurs in sandy pockets along stream banks, often in the shadow of *Kalmia* and *Rhododendron* rather than in association with *Drosera* or *Pinguicula*. The extremely restricted range of *S. oreophila* may be enlarged slightly by further study, but at present it is the only species completely disjunct from all other members of the genus *Sarracenia*. There are several unconfirmed reports of this species

from northwestern Georgia. Although there is no herbarium specimen of any *Sarracenia* from Tennessee, Gattinger reported its presence there and A. M. Jennison reports finding a plant of the genus *Sarracenia* in Fentress County, Tennessee, which may be *S. oreophila*, according to A. J. Sharp, who was with the group that found the plant and who later compared it mentally with *S. oreophila* in the greenhouse at the University of North Carolina.

2. **Sarracenia flava** L. Sp. Pl. **1:** 510. 1753.
 S. Gronovii var. *flava* Wood, Class Book, p. 222. 1861. Type loc. Va. to Fla. and La.
 S. Rugelii, Shuttlew. Msc. ex A. DC. Prod. **17:** 6. 1873.
 S. flava var. *atropurpurea* Hort. Bull, in Gard. Chron. 759. 1880.
 S. flava var. *atro-sanguinea* Hort. Bull ex André, Illustr. Hortic. **17:** pl. 386. 1880. Cat. Hort. Bull et Masters, Gard. Chron. ser. 2, **16:** 12. 1881.
 S. flava var. *limbata* Cat. Hort. Bull et Masters, Gard. Chron. ser. 2, **16:** 12. 1881.
 S. flava var. *maxima* Masters, Gard. Chron. ser. 2, **16:** 12. 1881.
 S. flava var. *minima* Masters, Gard. Chron. ser. 2, **16:** 12. 1881.
 S. flava var. *ornata* Cat. Hort. Bull et Masters, Gard. Chron. ser. 2, **16:** 12. 1881.
 S. Fildesii Hort. Nicholson, Dict. of Gard. **3:** 363. 1886.
 S. flava var. *Rugelii* Shuttlew. msc. ex Masters, Gard. Chron. **16:** 11. 1881.
 S. flava var. *media* Macfarlane in Engl. Das Pflanzenreich **4,** pt. 110: 31. 1908.

Summer leaves erect, elongate, trumpet-shaped with narrow linear wing, 4–12 dm. tall, expanding gradually from base to orifice; hood suberect, rounded, apiculate, narrow at base, edges revolute; color yellow, green or red, the first two often more or less reticulate with reddish-purple veins. Winter leaves ensiform, 2–4 dm. long. Scape usually slightly shorter than the summer leaves. Flowers with a strong musty scent; sepals green, 3–5 cm. long, widest near middle, rounded at broad apex; petals yellow, 5.5–10 cm. long (usually 5.5–7 cm.), narrowly obovate, slightly widened near base; style-disk 3–9 cm. broad (usually 4–8 cm.), the lobes 2-cleft at apex. Mature capsule 1–2.5 cm. in diameter.

Type locality: "Hab. in Americae septentrionalis udis."

Range: Bogs, swamps, low, open pine woods. Southeastern Virginia through eastern North Carolina and South Carolina to southeastern Georgia, thence west through southern Georgia and northern Florida to the vicinity of Mobile, Alabama.

Representaive specimens: VIRGINIA. New Bohemia, Prince George Co. *Wherry* (PENN); Cadayshore, Sussex Co. *Fernald* and *Long 6212* (PENN). NORTH CAROLINA. Kilkenny, Tyrrell Co. *Godfrey* and *Kerr* (DUKE 55389); Burgaw, Pender Co. *Bell* (CNC); Method, Wake Co. *Godfrey 3775* (CNC); Harmony, Iredell Co. *Radford 2633* (CNC); Lenoir, Caldwell Co.

Wherry (PH 753322). SOUTH CAROLINA. Hartsville, Darlington Co. *Smith* (CNC 26579); Georgetown, Georgetown Co. *Coker* (CNC 3104); Walterboro, Colleton Co. *Wherry* (PENN). GEORGIA. Graymont-Summit, Emanuel Co. *Wherry* (PENN); Alma, Bacon Co. *Harper 468* (PH); Quitman, Brooks Co. *Pyron* and *McVaugh* (DUKE 09238); Coolidge, Thomas Co. *Coker* and *Harbison* (CNC 31321). FLORIDA. Blountstown, Calhoun Co. *Bell* (CNC); Ponce de Leon, Holmes Co. *Lambert* (PENN); Crestview, Okaloosa Co. *Blanton* (US 1485419). ALABAMA. Kinston, Coffee Co. *Wherry* (PENN); Geneva, Geneva Co. *Wherry* (PENN).

S. flava is usually the first of the Sarracenias to bloom in any given locality within its range. The blooming season starts about March 15 at the southern limit of the range and ends near the last of May at the northern limits of the range and at the slightly higher elevations in the piedmont section of North Carolina.

The flowers of this species are bright yellow and have a strong musty scent not found in any of the other Sarracenias. Rarely the flower is erect instead of drooping, the petals in this case radiating to give the flower a somewhat star-shaped appearance.

This species does not have as great a range as *S. purpurea*, but is probably the most common of the genus, and shows more variety in leaf size and coloration than any other species of *Sarracenia*.

Some of these variations from the average are worthy of citation. Specimens of extreme size are: Fayetteville, Cumberland Co., North Carolina, *Wherry* (PENN), the leaves approaching 10 dm. in length; Wilmington, Brunswick Co., North Carolina, *Macfarlane* (PENN 49557), one leaf being 7.5 dm. tall and having a hood 13.5 cm. across; Ponce de Leon, Holmes Co., Florida, *Macfarlane* (PENN 38533), pitchered leaf only 6.5 dm. tall, but extremely broad at the upper portion, the hood being 14.7 cm. across. Specimens showing relatively extreme coloration are: Dalkeith, Gulf Co., Florida, *Moldenke 1148* (NY), leaf yellow, very little red at throat only; Santee, Charleston Co., South Carolina, *Bell 515* (CNC), leaf almost solid maroon.

Many of these variations have been given varietal rank by previous workers, but field observations and a study of herbarium material show that most of them are not definite or constant enough to be recognized as such and therefore are not given taxonomic importance here. Some such plants are: *S. Rugelii* Shuttlew. *Rugel*, Quincy, Gadsden Co., Florida (NY); *S. flava* var. *minima* Masters *Tracy*, St. Andrews Bay, Bay Co., Florida (PENN 49550); *S. flava* var. *ornata* Masters *Tracy*, St. Andrews Bay, Bay Co., Florida (PENN 49549).

It will suffice to say that the ascidiform leaves do vary not only from habitat to habitat but from clone to clone within a small habitat area. The most striking example of this was seen in a bog near Santee, South Carolina, where plants with clear yellow leaves, plants with solid red leaves and plants with leaves mottled to various degrees with red or maroon grew side by side.

Some extreme plants of *S. flava* have leaves of a solid dark red color. This very striking plant does not appear in isolated patches in a particular type of

habitat, but appears among extensive stands of typical yellow, green, or variegated-leaved *S. flava*. Although the proportion of plants with this extreme coloration is rather small in a given number of plants of *S. flava*, several hundred of them have been observed in an extensive stand of *Sarracenia* near Georgetown, South Carolina, and also in a stand near Santee, South Carolina. No plant of this variant of *S. flava* has ever been observed with flower or fruit or any evidence of either, although a pointed search was made for such evidence. This form does not appear to be basically an ecological form, but rather a genetic form with many intergrades between it and its solid green or yellow-leaved relatives. Macfarlane (1918) noticed that the red-leaved plants lost much of their red coloration when planted in the greenhouse. Such observations were also made by the present writer on plants brought in for this study. The extreme red coloration observed in some plants of *S. flava* in the field then seems to be a genetic capability rather than a genetic constant. Plants of this species that grow in somewhat shaded areas tend to have solid green leaves with only a reddish-purple band across the inner surface of the narrow neck of the hood and a minimum of red-purple reticulation around the orifice.

The range of *S. flava* overlaps or includes the ranges of all other species except *S. oreophila* and *S. Sledgei*. Of the six species thus within its range *S. flava* hybridizes with four (possibly more, but as yet unreported). See treatment of reported natural hybrids, *S. purpurea* x *flava*, *S. Drummondii* x *flava*, *S. minor* x *flava*, and *S. rubra* x *flava*.

3. **Sarracenia Sledgei** Macfarlane, Jour Bot. **45**: 4. 1907; Engl. Das Pflanzenreich **4**, pt. 110: 29. 1908.

S. Gronovii var. *alata* Wood, Class Book, p. 222. 1861. Type loc. Louisiana, *Hale*.

S. flava var. *crispata* Masters, in Gard. Chron. ser. 2, **16**: 12. 1881.

Summer leaves erect, elongate, trumpet-shaped with narrow linear wing, 2–8 dm. (usually 3–6 dm.) tall; hood suberect, ovate, apiculate with relatively straight inconspicuous red veins, edges flat or only slightly revolute. Scape about as long as the leaves. Sepals yellow-green, 2.5–5 cm. long, widest near base, tapering to narrow, blunt apex; petals light cream-yellow or greenish-yellow, fine-textured, 4–6 cm. long, obovate, often more or less revolute, distinctly expanded, measuring about 1.5 cm. across at its widest point; style disk 2.5–6 cm. in diameter, the lobes 2-cleft at apex. Capsule 1–2 cm. in diameter.

Type locality: West of Mobile River near Theodore, Ala., *Macfarlane*.

Range: More or less common in the southwestern quarter of Alabama west of the Mobile River and westward through southern Mississippi and Louisiana into the more humid areas of eastern Texas.

Representative specimens: ALABAMA. Deer Park, Washington Co. *Reade* (PENN 57861); Mobile, Mobile Co. *Macfarlane* (PENN 1542); Theodore, Mobile Co. *Bell 547* (CNC). MISSISSIPPI. Orange Grove, Jackson Co. *Bell 546* (CNC); Mississippi City, Harrison Co. *Canby* (US 369633). LOUISIANA. Abita Springs, St. Tammany Co. *Pennell* (PENN 58980). TEXAS.

Rust Co. (US 1468840); Tyler Co. *Whitehouse 756* (NY); Newbaden, Robertson Co. *Barkley 13006* (NY).

S. Sledgei, like *S. flava*, is the first of the pitcher plants to bloom within its range, being in full bloom near Mobile, Alabama, shortly after March 15 and continuing to bloom until the middle of April or possibly later further inland from the Gulf coast. The flowers of this species have a finer-textured petal than any of the other Sarracenias. Also this is the only species often having revolute petals, the majority of the plants observed in bloom just west of Theodore, Alabama, having petals more or less broadly revolute (Plate 13, figs. 2 and 3).

Before *S. Sledgei* was recognized and described as a new species by Macfarlane in 1908, it was considered to be *S. flava* or at best a western form of *S. flava*. However, the leaves are smaller and narrower than those of *S. flava* and seldom show the varied coloration or the revolute hood of that species. No plants of *S. Sledgei* seen in the field approached the dark red extreme possible in this species as evidenced by two of Macfarlane's collections: Ocean Springs, Jackson Co., Mississippi, *Macfarlane* (PENN 38501); Slidell, St. Tammany Co., Mississippi, *Macfarlane* (PENN 39673). In the first specimen the upper portion of the leaf and the hood are almost solid red; in the second specimen cited the leaf is colored to a lesser degree, but still has far more red pigmentation than average for *S. Sledgei*.

Although *S. Sledgei* is the only member of the genus *Sarracenia* found west of the Mississippi River, the eastern part of its range coincides with parts of the ranges of *S. Drummondii*, *S. purpurea*, *S. psittacina* and *S. rubra*; and in one small wet pasture south of highway U. S. 90 just west of Theodore, Alabama, *S. Sledgei* was found growing with the last three mentioned. It was at this location that what seems to be a previously unreported natural hybrid was collected, *Bell 2-29*. See treatment of natural hybrids *S. Drummondii* x *Sledgei* and *S. purpurea* x *Sledgei*.

4. **Sarracenia Drummondii** Croom, Ann. Lyc. Nat. Hist. **4**: 100. 1848.
   ?*S. lacunosa* W. Bartram, Travels, p. 417. 1791.
   S. leucophylla Raf. Fl. Ludov., p. 14. 1817.
   S. undulata Decne. Rev. Hort. **1**: 126. 1852.
   S. Gronovii var. *Drummondii* Wood, Class Book, p. 222. 1861.
   S. laciniata Kerner, Pflanzenleben, ed. 1, **1**: 118. 1887.

Summer leaves erect, elongate, trumpet-shaped with narrow linear wing, 4–12 dm. tall, the gradually expanding upper portion white, reticulate with red-purple veins; hood colored as upper portion of leaf, sub-erect, ovate or orbicular, margins undulate, contracted at base, inner surface more or less hispid. Winter or late summer leaves more or less numerous, ensiform or with extremely reduced pitchers and large linear wings, 2–6 dm. tall, in basal rosette. Scape erect, about as tall as the summer leaves. Sepals dark red, ovate, narrow apex slightly rounded, 2–4 cm. long; petals dark red, fiddle-shaped, usually widest at expanded basal portion, 4.5–7 cm. long; style disk 4–6 cm. in diameter, lobes 2-cleft. Capsule 1–2.5 cm. in diameter.

Type locality: Near the town of Appalachicola in Florida, *Drummond* in 1835.

Range: Southwestern Georgia and northern Florida near Tallahassee westward through northern Florida and southern Alabama into southeastern Mississippi. Common only in the southern half of the range, especially around Mobile, Alabama.

Representative specimens: GEORGIA. Americus, Sumter Co. *Wherry* (PENN). FLORIDA. Dead Lakes, Liberty Co. *Small* (US 1739079); Appalachicola, Gulf Co. *Moldenke 1177* (PENN); Fountain, Bay Co. *Bell 540* (CNC); Crestview, Okaloosa Co. *Macfarlane* (PENN 49350). ALABAMA. Flomaton, Escambia Co. *Macfarlane* (PENN 38510); Gateswood, Baldwin Co. *Tracy* (PENN 50666); Whistler, Mobile Co. *Graves* (US 1085034). MISSISSIPPI. Gulfport, Harrison Co. LeClair (CNC 3102).

S. Drummondii starts to bloom about the last week in March or slightly later than the other species of *Sarracenia* within its range. The main blooming period for the species as a whole is short, since it has a relatively small range restricted in depth from the Gulf coast and thus of a more or less uniform climate. The flowers of *S. Drummondii* are nodding at anthesis as are those of all the other members of the genus, but they commonly become more and more erect until they are perfectly erect by the time the petals drop. This habit was not observed (except in rare cases in *S. flava*) in any other species.

Color gradients are found in the foliage of *S. Drummondii* as in most other species of the genus, but do not seem to approach the dark red extremes often found in *S. purpurea* and *S. flava* except in rare cases. None of the dark red plants of *S. Drummondii* were observed in the field, but a plant of this color from Crestview, Florida, in Macfarlane's collection at the University of Pennsylvania and labeled *S. Drummondii* var. *atropurpurea* (*Macfarlane*, PENN 49355) seems to be a typical specimen of one extreme of color expression possible within the species. Another specimen from Deer Park, Alabama (*Reade*, PENN 57858) was labeled *S. Drummondii* var. *rubra*, but appeared to be of typical color with no excessive red pigmentation in the leaves. A plant approaching the lighter extreme of coloration had very pale green leaves with no red except along the veins in the hood and around the pitcher orifice. This plant was also collected at Deer Park, Washington Co., Alabama, and was labeled *S. Drummondii* var. *alba* (*Reade*, PENN 57857). All of the above plants are here considered as *S. Drummondii*. The differences in degree of red coloration are to be expected and should be noted, but not given taxonomic importance.

The white-topped leaves of *S. Drummondii* are very distinctive and offer a most striking color contrast to the usual bog vegetation. Harper (1918) says that the showy leaves have often been mistaken for the flowers by many nonbotanists. *S. Drummondii* grows in shady bogs or on moist sandy slopes. Its range, though small, coincides with parts of the ranges of every other species of *Sarracenia* except that of *S. oreophila*; and three different natural hybrids of *S. Drummondii* have been reported. See treatment of reported natural hybrids, *S. Drummondii* x *flava*, *S. Drummondii* x *purpurea* and *S. Drummondii* x *Sledgei*.

5. **Sarracenia rubra** Walt. Fl. Carol., p. 152. 1788.
S. Gronovii var. *rubra* Wood, Class Book, p. 222. 1861.
Type loc. Va. to Fla. and La.
S. minor Sweet, Brit. Flower Gard. ser. 2., t. 138. 1831–38.
S. Sweetii DC. Prodr. 17: 5. 1873.
S. rubra var. *acuminata* DC. Prodr. 17: 4. 1873.

Leaves numerous, dull green, usually finely but profusely reticulated with maroon-purple around the orifice and inner surface of the hood, 1–5 dm. long, narrow pitcher expanding gradually from base to orifice; hood suberect, ovate, acuminate, usually more or less closely covering orifice, not contracted at base; wing narrow, usually linear, sometimes slightly wider at or below the middle. Scape erect, usually taller than leaves. Flowers sweet-scented; sepals maroon on outside with green inner surface, ovate, 2–3 cm. long, obtuse, very strongly recurved soon after the petals fall; petals maroon, often yellow-green tinged with red on inner surface, 2.5–4 cm. long, obovate, often extremely so; style disk 2–3.5 cm. in diameter, 2-cleft at apex. Mature capsule 0.5–1.5 cm. in diameter.

Type locality: South Carolina.

Range: Not common, usually in relatively small, inconspicuous patches in bogs, swamps, and open pine or mixed forests from southeastern corner of North Carolina southwest in a broad band across South Carolina into central Georgia and on into western Florida, southern Alabama and southeastern Mississippi. The disjunct range centering around De Funiak Springs, Florida, shown by Wherry in his series of distributional maps for the species of *Sarracenia* seems to have been delimited too closely, a group of plants of *S. rubra* having been collected in connection with this work west of Theodore, Alabama (*Bell 2-27*). Studies of herbarium material have tended further to break down the argument for disjunct ranges for *S. rubra* and *S. jonesii* as listed by Wherry (Plate 12).

Representative specimens: NORTH CAROLINA. Vass, Moore Co. *Bell 521* (CNC); Wilmington, Brunswick Co. *Wherry* (US 1466408). SOUTH CAROLINA. Hartsville, Darlington Co. *Smith 276* (CNC); Georgetown, Georgetown Co. *Godfrey* and *Tryon 210* (PENN); St. Mathews, Calhoun Co. *Schallert* (DUKE 01801). GEORGIA. Erick, Montgomery Co. *Harper* (NY); Ohopee, Tattnall Co. *Harper* (US 511165); Toadover Creek, Macon Co. *Reynolds* (PH 745311). FLORIDA. Deerland, Okaloosa Co. *Bell 526* (CNC); Crestview, Okaloosa Co. *Leeds* (PH 724843). ALABAMA. Bay Minette, Baldwin Co. *Macfarlane* (PENN 39682); Theodore, Mobile Co. *Bell 576* (CNC). MISSISSIPPI. Waynesboro, Wayne Co. *Pollard* (NY).

S. rubra is a rather late-blooming species, not being in full bloom until the last half of April at the southern limits of its range and not blooming until mid-May in North Carolina. The flowers have a sweet scent similar to that of violets, and are small and rather delicate when compared to the sturdy, odorless flowers of *S. purpurea*. The sepals of *S. rubra* are more strongly recurved, and begin to recurve at an earlier date after anthesis than in any other species of *Sarracenia* (Plate 11, fig. 3). *S. purpurea* is at the other extreme, rarely showing any tendency of the sepals to recurve (Plate 11, fig. 2). The petals of *S. rubra* also differ from those of all other plants of the genus by being extremely obovate,

the distal lobe often being twice the width of the basal lobe and as much as five times the width of the narrow neck between the two lobes (Plate 11, fig. 1). A double-flowered plant of this species was reported from South Carolina by W. C. Coker (Plant World **12**: 253. 1909). The leaves of *S. rubra* are dull green with the only coloration being the maroon lip of the orifice and the light reticulation of the hood; thus they are not at all showy, and their small size makes the isolated clumps hard to spot in the field.

Like all the pitcher plants, *S. rubra* is a hydrophyte, but it has been collected in several localities that seemed slightly drier than usual. The linear southwest-northeast range of *S. rubra* coincides with parts of the ranges of all other plants of the genus except *S. oreophila*. Yet only two natural hybrids have been reported; see *S. purpurea* x *rubra* and *S. rubra* x *flava*.

5a. **Sarracenia rubra** forma **jonesii** (Wherry) n. comb.

S. jonesii Wherry, Journ. Wash. Acad. Sci. **19**: 385. 1929. Type loc. south of Flat Rock Station, Henderson Co., N. C., *Wherry* in 1922 (US 1438266).

Differs from species type in usually having longer leaves that are more distinctly expanded toward the orifice (Plate 11, figs. 4 and 5). The hood may also be somewhat higher over the orifice than in *S. rubra*.

Type locality: Moist meadow 1.5 miles south of Flat Rock Station, Henderson County, North Carolina.

Range: Scarce in wet meadows and along stream banks in an isolated northern section of its range, including Buncombe and Henderson counties in North Carolina and Pickens Co. in South Carolina. Occasional throughout the range of *S. rubra*, but more common in its coastal range of southern Alabama, the western portion of northern Florida and extreme southeastern Mississippi.

Representative specimens: NORTH CAROLINA. Flat Rock, Henderson Co. *Wherry* (US 1438266); Biltmore, Buncombe Co. Biltmore Herbarium 3374a (NY). SOUTH CAROLINA. Mtn. Lake, Pickens Co. *Bell 573* (CNC); Kershaw, Lancaster Co. *House* (US 514174); Strother's Pond, Batesbury, Saluda Co. *McGregor* (US 1074983); Sumter Co. *Holdaway 29* (DUKE 42645). GEORGIA. Ohopee, Tattnall Co. (NY). FLORIDA. Margins of swamps, Walton Co. *Curtiss* (US 3031). ALABAMA. Jasmine, Chilton Co. *Harper* (US 1085323); Deer Park, Washington Co. *Reade* (PENN 57854). MISSISSIPPI. Poplarville, Pearl River Co. *Langman 1937* (PENN); Saucier, Harrison Co. *Oosting 1892* (DUKE).

S. rubra forma *jonesii* blooms the latter half of April with *S. rubra* in its southern range, and the last two weeks of May in its northern mountainous range. The flowers of the form are exactly like those of the species, having the sweet scent, extremely obovate maroon petals, and the strongly recurved sepals of typical *S. rubra*. The leaves of the form, as mentioned above, differ somewhat from those of the species; but leaf shapes intermediate between the two are so common in southern Alabama and northwestern Florida that it is difficult to classify any but those near the extremes (Plate 11, fig. 6).

The main difference between *S. rubra* and Wherry's species *S. jonesii* seemed

to be one of size, many large specimens with typical *S. rubra* leaf form being labeled *S. jonesii* (by Wherry) in the various herbaria. Since leaf size is seen to vary greatly in several other species, notably *S. minor* and *S. flava*, it should not be given too much importance in species delimitation. The only factor considered here in separating *S. rubra* from forma *jonesii* is leaf shape. Any plant within this species having leaves that are in general sharply expanded toward the rather exposed orifice (Plate 11, figs. 5, 6a & b) are placed in the *S. rubra* forma *jonesii* classification, and any plants with leaves in general conforming to a more uniform taper toward the more or less closely covered orifice (Plate 11, figs, 4, 6c & j and Plate 13, fig. 4) are considered typical of *S. rubra*. Often the leaves of forma *jonesii* are taller than those of the species, but this is not always true (Plate 11, fig. 6d). In so far as most intergrades tend toward the species characteristic they are classified with this taxonomic unit rather than with the form (Plate 11, fig. 6e, f & g).

No plants of Wherry's *S. jonesii* could be found at the type locality. Living plants sent to me by Mr. Rodgers from a location in Pickens County, previously reported by the late Dr. Ives, had leaves so similar to typical *S. rubra* that positive identification could not be made at that time. Later the plants produced a few of the larger leaves upon which the form is based (Plate 13, fig. 8). Plants subsequently observed in Pickens County, South Carolina, also had both types of leaves. And some plants of typical *S. rubra* from Moore County, North Carolina, grown in the greenhouse have shown a tendency to produce leaves with more sharply expanded upper portion and hoods more erect than usual (Plate 13, fig. 5).

From the relatively small amount of living and herbarium material available for the study of *S. rubra* forma *jonesii* as it occurs in the mountains of North and South Carolina it appears that it is the dominant, if not only, expression of the species in this area (Plate 13, fig. 8). However, since its floral characteristics are identical with those peculiar only to *S. rubra*, and since the ranges of the two types coincide at other locations, the large-leaved plants are not here considered of specific importance.

6. **Sarracenia minor** Walt. Fl. Carol., p. 153. 1788.
   S. lacunosa Bartr. Travels, p. 417. 1791.
   S. variolaris Michx. Fl. Bor. Am. **1**: 310. 1803.
   S. adunca Smith, Exot. Bot. **1**: 103. 1804.

Leaves erect, usually 2–6 dm. long, gradually expanding upward from the base; outer edge of wing almost straight from base of leaf to orifice, being extremely narrow at these two extremes and widest in the middle, the curve of the wing thus complementing the curve of the tubular portion of the leaf; hood ovate, arching, incurved over orifice, hood and upper portion of leaf heavily maculated with white or opaque blotches and variegated with green and red-purple veins. Scape erect, usually shorter than the leaves. Sepals ovate, 1–3 cm. long, obtuse; petals narrowly fiddle-shaped, clear yellow, the slightly expanded basal portion often being more or less red, especially on the inner surface; style disk 2–3 cm. in diameter, 2-cleft at the apex. Mature capsule 0.75–1.5 cm. in diameter.

Type locality: "From South Carolina to Florida."

Range: Common in bogs, swamps, low fields, and open pine woods from the southeastern corner of North Carolina near Wilmington through the southeastern half of South Carolina and Georgia almost to Alabama, thence through northeast Florida and southward in central and east coastal peninsular Florida to the Everglades (?).

Representative specimens: NORTH CAROLINA. Fayetteville, Cumberland Co. *Clark* (DUKE 92956); Columbus Co. *McCarthy* (US 3034); Southern Pines, Moore Co. *Harriot* (PH 815525). SOUTH CAROLINA. Hartsville, Darlington Co. *Smith* (CNC 26578); Sumter Co. *Harper* (NY); Manning, Clarendon Co. *Godfrey* and *Tryon* (US 1837684); Georgetown, Georgetown Co. *Bell 577* (CNC); Summerville, Dorchester Co. *Hollinhead* (PENN 1568). GEORGIA. Statesboro, Bulloch Co. (DUKE 33967); Lyons, Toombs Co. *Oosting* (DUKE 49600); Waycross, Ware Co. *Bell 527* (CNC); Okefenokee, Ware Co. *Harper 1476* (NY) also *Bell 529* (CNC); Leesburg, Lee Co. *Wherry* (PENN). FLORIDA. Penney Farms, Clay Co. *Totten* (CNC 28973); Oviedo, Seminole Co. *Walker 1756* (PENN); Kissimee, Osceola Co. *Williams* (PH 636964); Sebring, Highlands Co. *Correll* and *McFarlin* (DUKE 46244); Tallahassee, Leon Co. *Ashe* (CNC 31311).

S. minor is intermediate in blooming date north of peninsular Florida, where its range coincides with other plants of this genus, blooming the last two weeks in April at the southern limit of its mainland range and slightly later further north and/or inland. The flowers of *S. minor* are odorless, clear yellow (Walter's first but unpublished name for this species was *S. lutea.*), and vary greatly in over-all size, depending upon the size of the plant. The petals, for instance, averaging 2.5-4 cm. in length for the smaller or average size plant and averaging 4.5-6 cm. in length for the large plants found in the Okefenokee Swamp in southeastern Georgia. The large plants collected by boat in the Okefenokee are similar to the typical *S. minor* of drier habitats in every respect except size. Some of the plants collected had leaves ten or more decimeters long and were growing on (or in) floating "islands" of rotting vegetation in the swamp. The first new set of leaves put out by these same plants growing under somewhat drier conditions in the greenhouse averaged less than 7.5 dm. However, the smaller *S. minor* plants collected in an open pine field only a few miles outside the Okefenokee did not show any appreciable increase in the leaf size when grown in the greenhouse although they probably received as much or possibly more water than in their native habitat. The extremely large plants of *S. minor* found in the Okefenokee Swamp and mentioned by several previous writers thus seem to be only an ecological form, dependent upon habitat for their singular variation.

Yet not all plants from the Okefenokee have extremely large leaves. One plant collected in bloom in this area, *Reade* (PENN), had leaves only 14 cm. long. Quite a few plants of *S. minor* on file from areas other than the Okefenokee Swamp approached the size of the average plants of this area, one from Myrtle Beach, Horry Co., South Carolina (*Doubles et al.*, CNC 10820) having a leaf 42 cm. long.

A plant collected by R. M. Harper in Coffee Co., Georgia, was originally labeled *S. lacunosa* (*Harper*, US 384553), but had been annotated "minor" by some later observer. It looked like typical *S. minor*.

S. minor does not grow very far westward, its range bulging inland from the Atlantic coast to a point near Tallahassee, Florida. This lack of longitude is more than compensated for in its range of latitude, however, since the plant is found from North Carolina to Florida and is the only one of the genus really to penetrate peninsular Florida. Its range is coincident with parts of the ranges of *S. flava*, *S. psittacina*, *S. purpurea*, *S. rubra* and *S. Drummondii*, hybrids between *S. minor* and the first two having been reported. See *S. minor* x *flava* and *S. minor* x *psittacina*.

7. **Sarracenia psittacina** Michx. Fl. Bor. Amer. **1:** 311. 1803.
S. calceolata Nuttall, Trans. Amer. Phil. Soc. ser. 2, **4:** 49. 1834.
S. pulchella Croom, Amer. Jour. Arts. Sci. **25:** 75. 1834.

Leaves numerous, 0.5–2.5 dm. long, evergreen, more or less decumbent, in basal rosette; hood globose, keel-shaped or pointed toward ventral edge of leaf, numerous small, colorless, opaque patches on dorsal curve of hood; orifice small, round, lateral, completely covered by expanded hood; wing usually prominent, broadest just above the middle; leaves green, variegated more or less heavily with red. Scape erect 2–3.5 dm. tall. Sepals ovate 2.0–2.5 cm. long, obtuse, green or dark red on outside; petals 2–4 cm. long, obovate, apex rounded or retuse, maroon; style disk 2–3.5 cm. in diameter, lobes 2-cleft. Mature capsule 5–12 mm. in diameter.

Type locality: "Ab urbe Augusta Georgiae ad Floridam."

Range: Fairly plentiful in bogs and open lowlands south of the Savannah River in Georgia, all of northern Florida, and west through southern Alabama into Mississippi and Louisiana.

Representative specimens: GEORGIA. Millen, Jenkins Co. *Wherry* (PENN); Coolidge, Thomas Co. *Coker* (CNC 31305). FLORIDA. St. James Island, Franklin Co. *Correll 5660*; Bloxham, Liberty Co. *Bell 535* (CNC); Milligan, Okaloosa Co. *Macfarlane* (PENN 49324). ALABAMA. Bay Minette, Baldwin Co. *Macfarlane* (PENN 38490); Theodore, Mobile Co. *Bell 534* (CNC). MISSISSIPPI. Ocean Springs, Jackson Co. *Pollard* (US 271560); Biloxi, Harrison Co. *Tracy* (US 341105). LOUISIANA. Covington, St. Tammany Co. *Peterson* (NY), also *Arsine* (US 1031876).

Since *S. psittacina* has a somewhat restricted range of latitude, its blooming season is likewise limited, beginning about April 1 and reaching its peak the last two weeks of that month. Its main blooming season is thus slightly later than those of *S. flava*, *S. Sledgei*, *S. Drummondii*, and *S. purpurea* in the same area.

The flowers of this species are consistently of the same shade of red or light maroon as those of *S. rubra* and do not show the effect of varied light intensities as do many of those of *S. purpurea*. The leaves, however, do show the effect of strong sunlight. Leaves of plants growing in shaded locations tend to be longer, greener, and have smaller hoods than those grown in the sun, which are

often found with large hoods and almost solid red leaves. The Okefenokee Swamp habitat has produced at least one extreme plant of *S. psittacina* as well as the large plants of *S. minor*. The specimen of *S. psittacina* above cited has long, slender leaves, one reaching a length of 27 cm. (Chesser Prairie, Okefenokee Swamp, Georgia, *F. Harper* (PH 768769)). The expanded hood of *S. psittacina* is very much like that of *Chrysamphora californica*, lacking only the two-winged appendages of the latter to be its duplicate in form. The orifice of the narrow pitcher of *S. psittacina* differs from that found in any other species of the genus in that it is lateral rather than terminal. This modification would seem to reduce the chances for the insect to escape when once inside the leaf.

Although the range of *S. psittacina* is not too extensive, it is coincident with parts of the ranges of every other species of the genus except *S. oreophila*. Despite this broad association and the lack of positive isolating mechanisms (*S. psittacina* has been crossed with *S. Drummondii*, thus uniting the morphological extremes of the genus), only one natural hybrid has been reported with *S. psittacina* as a parent. See section on natural hybrids, *S. minor* x *psittacina*.

8. **Sarracenia purpurea** L. Sp. Pl., p. 510. 1753.

Sarazina gibbosa Rafinesque, Autikon Botanikon, p. 33. 1840. Type loc. Canada to Virginia, swamps.

Sarazina venosa Rafinesque, Autikon Botanikon, p. 33. 1840. Type loc. Virginia to Florida.

S. purpurea var. *typica* Macfarlane, in Engl. Das Pflanzenreich **4**, pt. 110:33. 1908. Type loc. Manitoba to Florida.

S. purpurea venosa (Raf.) Wherry, Bartonia **15**: 3. 1933.

S. purpurea gibbosa (Raf.) Wherry, Bartonia **15**: 5. 1933.

Leaves evergreen, all of one type, 0.5–3.5 dm. long (or to 4.5 dm. in extreme cases in which event the petiole is long and slender, the pitchered portion of the leaf being the distal half only), decumbent, disposed in basal rosette, green, often more or less variegated with purple-red, but rarely clear yellow-green; pitcher ventricose; ventral wing widest near middle; orifice completely exposed due to erect position of the broadly cordate, repand hood. Scape erect, 1.5–4 dm. tall. Sepals maroon, green or yellow, ovate, 2–4 cm. long, never strongly recurved; petals more or less maroon, rarely yellow, fiddle-shaped, 4–6 cm. long, obtuse; style disk 3–4 cm. broad, the lobes notched. Mature capsule 1–2 cm. in diameter.

Type locality: "Hab. in Americae septentrionalis udis."

Range: Peat bogs from east central Canada to Pennsylvania and Maryland: low open pinelands of Virginia, North Carolina, northeastern half of South Carolina, and bordering the Gulf of Mexico in Georgia, northern Florida, Alabama, Mississippi, and Louisiana (?).

Representative specimens: (The symbol (S) is used to indicate plants from the northern range of Wherry's geographic subspecies that have the foliage characteristic of the southern subspecies; (I) indicates leaves intermediate between northern and southern type of plant as listed by Wherry.) SAS-

KATCHEWAN. Lake Athabaska, *Raup 6974* (NY). ONTARIO. (S) Sauble Beach, Lake Huron, *Wherry* (PENN); (I) Peterboro, Peterboro Co. *Wherry* (PENN). QUEBEC. Grindstone, Grindstone Island, *Fernald* (PH 734614); St. Jean Sur Le Lac, La Belle Co. *Pennell* (PH 737460); Roches Lake, Quebec Co. *Marie-Victorin* (US 872545). LABRADOR. (I) Northern Labrador, *Kenaston* (US 3021). NEWFOUNDLAND. (S) Whitbourne, *Robinson & Schrenk* (US); Exploits River Valley, *Fernald* (NY). NOVA SCOTIA. (S) Canso, Guysborough Co. *Fowler* (US 432916); Young's Lake, Annapolis Co. *Bell 561* and *562* (CNC); (S) Tiddville, Digby Co. *Fernald & Long* (PH 588448). MINNESOTA. (I) Duluth, St. Louis Co. *Lakela 2983* (PENN); Benedict, Hubbard Co. *Bergman 3046* (PENN). WISCONSIN. Eagle River, Vilas Co. *Lyon* (US 1630725); Marshland, Buffalo Co. *Holzinger* (PENN). MICHIGAN. (S) Manistique, Schoolcraft Co. *Pennell* (PH 764941); (I) Cecil Bay, Emmet Co. *Ehlers* (PH 655618); Haslet, Ingham Co. *Yunker* (US 1200855). ILLINOIS. Chicago, Cook Co. *Jaeger* (PH 752279). INDIANA. Leesburg Swamp, Kosciusko Co. *Wann* (PENN); Mineral Spring Station, Porter Co. *Wherry* (PENN). OHIO. (S) Canton, Stark Co. *Stair* (NY); (S) Silver Lake, Logan Co. *Stair* (US 310919). PENNSYLVANIA. (S) Lehigh Pond, Wayne Co. *Adams 3711* (PENN); (I) Gelatt, Susquehanna Co. *Glowenke 2302* (PENN). NEW HAMPSHIRE. Shelbourne, Coos Co. *Moore 4132* (PENN); Indian Pone, Grafton Co. *Reed* (DUKE 24656); (S) Petersborough, Hillsborough Co. *Batchelder* (PH 546097). VERMONT. Garden of Eden, Lamoille Co. *Knowlton* (PH 562838); Peacham, Caledonia Co. *Stevens* (US 310915). NEW YORK. (S) Argyle, Washington Co. *Schaeffer* (PH 791260); Cragsmoor, Ulster Co. *Farr* (PENN 46926); Conquest, Cayuga Co. *Wiegand* (PH 674040). MASSACHUSETTS. (S) Canton, Norfolk Co. *Standley & Blake* (US); (S) Petersham, Worcester Co. *Hough* (PENN); (S) Provincetown, Barnstable Co. *Fernald & Long* (PH 582163). MAINE. Arson Is., Oldtown, Penobscot Co. *Fernald & Long* (PH 574698); North Berwick, York Co. *True 213* (PENN). CONNECTICUT. (S) Eagleville, Tolland Co. *Travis 1960* (PENN); East Thompson, Windham Co. *Beals* (PH 618345). RHODE ISLAND. (S) Quidneset Point, *Bennett & Bailey* (DUKE 76047). NEW JERSEY. Green Pond, Warren Co. *Fritz* (PH 555546); Toms River, Ocean Co. *Bell 567* (CNC); Porchtown, Salem Co. *Foag 7071* (PENN). DELAWARE. Concord, Sussex Co. *Fisher* (PENN). MARYLAND. (S) Sharptown, Wicomico Co. *Wherry* (PENN); (S) Laurel, Prince George Co. *Marshall* (US 310917). VIRGINIA. Brunswick Co. *Va. Acad. Sci. Party* (PENN). NORTH CAROLINA. New Bern, Craven Co. *Radford & Stewart 1118* (CNC); Wilmington, Brunswick Co. *Radford 657* (CNC); Method, Raleigh, Wake Co. *Godfrey 3778* (CNC); Rocky Face, Alexander Co. *Totten* (CNC 3099); Cuba, Rutherford Co. *Lynch* (CNC 31347); Highlands, Macon Co. *Coker* (CNC 31348). SOUTH CAROLINA. Hartsville, Darlington Co. *Smith 877* (CNC); Georgetown, Georgetown Co. *Coker* (CNC 3106); Poinsett State Park, Sumter Co. *Blomquist & Holloway* (DUKE 53367). GEORGIA. Rabun Bald, Rabun Co. *Pyron* (DUKE 55857); Tattnall

Co. *Harper* 2151 (US). FLORIDA. Myron, Calhoun Co. *Moldenke 1158* (PENN); Fountain, Bay Co. *Bell 580* (CNC). ALABAMA. Bay Minette, Baldwin Co. *Bell 579* (CNC); Theodore, Mobile Co. *Bell 578* (CNC). MISSISSIPPI. Orange Grove, Jackson Co. *Oosting* (DUKE 49605).

S. purpurea, known in print since 1601, and the species upon which the genus was founded, is probably not the most numerous in number of individual plants since it does not occur in the large "*Sarracenia* meadows" of thousands of plants as do some of the other species; but it is by far the most widespread, being found, roughly speaking, from the subarctic to the sub-tropics, and extending sporadically near its northern limits from longitude 60° west to longitude 95° west. It blooms at the southern limits of its range the last two weeks of March and at proportionately later dates further north, blooming the last of August at the northern limits of the range. The flowers range in color from light red-purple (with green sepals) to extremely dark flowers in which both petals and the outer surface of the sepals are a very dark rich maroon. Although Wherry (1933) in delimiting the two subspecies of *S. purpurea* assigns the lighter colored flowers to the southern subspecies, the plants that produced the darkest flowers observed in the field in the present study were from near Bay Minette, Alabama (*Bell 2-30*). They were in full sun, as have been most other very dark red-flowered plants of this species observed. The only two plants of *S. purpurea* observed with uniformly dark red foliage were collected near White Lake, North Carolina, from a low area fully exposed to the sun and surrounded by pure white sand. These plants had very dark red blooms, but when brought into a more shaded location in the greenhouse subsequent blooms and foliage were observed to have noticeably less red pigmentation. This duplicated the observations of Macfarlane (1908) who noticed that plants growing in less open situations (or possibly only in cooler ones) usually have less red pigmentation in the leaves and tend to have lighter blooms than those plants of this species grown in full sun. In this connection a plant of *S. purpurea* similar to one discovered by F. M. Jones near Theodore, Alabama, in 1910 and described as a "color form" or mutant by Wherry was collected (*Bell 2-12*) during some recent field work near Fountain, Florida. The plant had light green sepals, pink petals and a pure white style disk. It was growing in a sphagnum clump in a densely shaded magnolia swamp. Other collections and field observations indicate that there is a direct relation between sun (and possibly temperature) and the degree of red pigment in plants of *S. purpurea*, the plants in full sun having redder foliage whenever the plant is genetically capable of the production of red pigmentation. No case has been found where plants of this species growing side by side in a given habitat will have leaves at the two extremes of the color range, i.e. solid green or solid red, as is often found in certain growths of *S. flava.*

The other characteristic used by Wherry for his subdivision of the species was leaf form, which appears none too constant in various herbarium specimens. The characteristic leaf type "the hollow part averaging over three times as long as wide; hood relatively small, its wings, when laterally flattened, extending little if at all beyond the pitcher-lip," which was assigned to the northern subspecies

S. purpurea gibbosa by Wherry (1933), is also found among plants in the southern areas of the range of *S. purpurea*, especially in the piedmont and mountains of North Carolina where ecological conditions approach, somewhat, those of higher latitudes. Peat bogs, which usually foster such variations as Wherry ascribes to the northern subspecies, are far more common in the north than the coastal plain savannah type of bog and therefore might possibly be the sole factor causing the modification of leaf characters. Appropriate reciprocal transplants will be made, but meanwhile the growth of the two types of *S. purpurea* under uniform conditions in the greenhouse may give a hint as to the outcome of the reciprocal transplant experiment. If the elongate leaf shape then remains constant on the northern long-leaved plants and if the seed collected in the field from such plants produces more long-leaved *S. purpurea* it will then have been proved that the characteristic is genetic rather than ecological. In such a case the two subspecies of Wherry would seem justified. However, it appears at this time that the minor differences between specific plants of *S. purpurea* are more environmental than hereditary, plants of a given morphological form being found throughout the entire range wherever the proper ecological factors necessary for its expression are found. Also many plants with intermediate leaf forms, or with leaves on the same plant definitely of both forms, are found throughout the range of this species, especially the northern range. For this reason the species is not considered here to be made up of two geographic subspecies, note being made, however, as to the extreme length often, but not always, attained by some plants from various localities, especially those in the higher latitudes.

In the southern portion of its range, from Virginia southward, *S. purpurea* grows at one station or another with every other species of *Sarracenia* except *S. oreophila*. Three different natural hybrids involving *S. purpurea* as a parent have been previously reported; and what is probably a new one is reported for the first time in the section of this paper on natural hybrids. See *S. purpurea* x *flava*, *S. purpurea* x *rubra*, *S. purpurea* x *Drummondii*, *S. purpurea* x *Sledgei*. and *S. purpurea* x *rubra* forma *jonesii*.

8-a. **Sarracenia purpurea** forma **heterophylla** (Eaton) Fernald, Rhodora **24**: 174. 1922.

S. heterophylla Eaton, Manual of Bot. for N. A. ed. 3, p. 447. 1822. Type loc. In swamps, Northampton, Mass.

S. purpurea heterophylla (Eaton) Torrey, Rept. Bot. Dept. Survey N. Y. Assembly No. 50: 120. 1839.

Differs chiefly from *S. purpurea* in that the flowers are yellow, and the leaves lack any trace of red, being yellow-green; the hood especially often turning a rich gold at maturity.

Type locality: In swamps, Northampton, Massachusetts.

Range: In small isolated colonies in Newfoundland, Nova Scotia, and possibly Massachusetts and New Jersey. Rare, except at locality given by Fernald in recognizing the plant as a form.

Representative specimens: NEWFOUNDLAND. Main Arm, Bonne Bay, *Fernald & Long* (PH 803203); Exploits River and Badger Brook, *Robinson & Schrenk* (US 217053). NOVA SCOTIA. Young's Lake, Belle Isle, Annapolis Co. *Fernald* (PH 588937), also *Bell 557* (CNC). NEW JERSEY. Forked River, *Britton* (NY).

This plant is here restored to the rank given it by Fernald in 1922 mainly because field observations and a review of the literature and herbarium material indicate it to be a small but constant and definite breeding entity of limited geographical range clearly within the structural and distributional limits of *S. purpurea*.

It was first named and described by Eaton in 1822 from a locality in Massachusetts. He termed it "A remarkably distinct species, but very rare." Later workers have variously reduced the rank of the plant from species to subspecies to variety to form to mutation, and finally Wherry (1933) has split the plant, considering the leaves to be "a slender-leaved ecad" and the flower "an anthocyan-free mutation."

Fernald in his "Notes on the Flora of Nova Scotia" says that the plant "occurs abundantly at the boggy margin of Young's Lake, . . .". This is indeed true, the plant being present in relatively large numbers and growing side by side with plants of *S. purpurea* that have leaves typically red or red-green. The degree of red coloration in these plants varied, but even where it was almost absent the leaves did not have the peculiar yellow hue so characteristic of forma *heterophylla*. This yellowness is almost lost when specimens are pressed. Therefore identification of pressed material is often difficult or even impossible, the pure green leaves of "shade grown" *S. purpurea* often appearing like the yellow-green leaves of the form when pressed. One thing can be used in a negative way, however, since *any* trace of red in the leaves *or* petals immediately prevents it from being classed as forma *heterophylla*. This point invalidates most of the *S. heterophylla* collected by Schallert in eastern North Carolina. The remaining plants so labeled, although showing no red, are therefore discounted as probably "shade plants."

In reinstating Fernald's form of *S. purpurea* the author does so with the feeling that it may actually deserve higher taxonomic rank. This is not just because the flower is reported to be yellow, but because it is felt that a plant which has through some evolutionary process evolved completely away from not only a specific but even a generic or possibly family characteristic (the production of anthocyans), and has become established as a breeding entity in an area already populated by another successful member of the genus, should have taxonomic importance. To call such a plant an anthocyanin-free mutation is proper so long as only one or two individuals occasionally occur and do not become established. But when such a "mutation," as it might well be, becomes a definite, reproducing (and probably geographically expanding) unit of the species population it should have recognition. Although its initial range is small, such a plant in following the cycle of mutation-reproduction-establishment is following one basic path toward speciation and should not be left out of consideration.

HYBRIDS IN NATURAL POPULATIONS

Although Harper (1918) reported some hybrid *Sarracenia* plants growing in localities isolated from the suspected parent forms, one would be safe in assuming that the first requirement for hybridization of these plants would be that the parent types involved in the cross grow more or less in the same local area. The fulfillment of this requirement, of course, does not guarantee that hybrids of the parent species will occur, as there are often physiological and/or morphological barriers between two species of the same genus. Such isolating mechanisms, however, are extremely weak or as yet not developed in most of the members of the genus *Sarracenia*; and as a result, geographical isolation seems to be the only truly effective barrier. The only species not found to be the parent of at least one hybrid is, therefore, *S. oreophila* which has a range completely isolated from other members of the genus. *S. purpurea*, on the other hand, is the recognized parent of five natural hybrids, and as might be suspected, has the most general and extensive range of any *Sarracenia*. If *S. purpurea* is the most evolved form, as suggested by Russell (1919), it would appear that little if any of its evolutionary capabilities have been used to develop positive isolating mechanisms. *S. flava* is involved in only three natural crosses, but it seems to cross readily when under cultivation as do all other species of *Sarracenia*. Note the following cross reported by Macfarlane (1908): [(*purpurea* x *flava*) x *purpurea*] x (*purpurea* x *psittacina*). Offspring of natural backcrosses have been observed and reported by Macfarlane, Harper, Russell, Wherry, and others. The first two noticed and reported on the intermediate character of *Sarracenia* hybrids, and in 1919 Russell published a paper on the comparison of hybrids with their parents. The summary was, in brief, that the hybrids are not only intermediate between the parents in grosser morphological characteristics, but also, with few minor exceptions, are intermediate in cellular detail as well. There appears to be no case of complete dominance in any hybrid, parental characteristics being visible after backcrosses as well as crosses.

Macfarlane found one hundred and seventeen plants of *S. purpurea* x *flava* in one day in Holmes county, Florida, which probably sets a record for that particular combination; but the most numerous hybrid is probably *S. Drummondii* x *Sledgei*. These two species overlap in southwestern Alabama between Mobile and the Alabama-Mississippi line, and within this area are actually thousands of these hybrids as well as all possible backcrosses. *S. Drummondii* and *S. Sledgei* interbreed as freely as if they were of the same species despite their morphological differences, and this may lead in time to the development of a new species in this locality. The first requirement of any such species would be a positive isolating mechanism. Otherwise its identity would soon be lost, due to the extreme gene flow between the parent plants under consideration in this area.

Unless the yellow form of *S. purpurea* occurred in a small population of *S. purpurea* or unless it quickly developed an isolating mechanism, it seems likely that it would have lost its identity.

The close relationship of the members of the genus *Sarracenia* is accentuated

by their ability to interbreed, and taxonomic problems are complicated by the resulting slow differentiation along various lines of evolution.

Since thirteen different natural combinations have been reported and since these hybrids are not too uncommon and can be recognized as definite units in the population, they are treated briefly here. The dozens of horticultural hybrids that have been reported are omitted. However, the most generally accepted horticultural name applied to any particular hybrid has been listed. Such names usually were applied to specific horticultural hybrids before the wild hybrid of the same parentage had been reported. No attempt has been made to record other horticultural data; and the order in which the natural hybrids are listed follows no special sequence, this order merely being most convenient for the author. Recognition is given to the first person to find and report each hybrid, and subsequent reports have not always been listed in this paper if the hybrid appeared to be more or less common.

Although there is no dominance involved in such hybrids, the gibbous character of *S. purpurea* is usually immediately evident, as is the white, undulate hood of *S. Drummondii*. For this reason they are listed first in any cross between them and any other species.

Conspicuous by their absence are reported natural hybrids of *S. Drummondii* x *psittacina*, *S. Drummondii* x *minor* and *S. minor* x *purpurea*, all of which have been made under cultivation, and all of which are possible as far as coincidence of range is concerned. Perhaps they will be reported in the future.

S. purpurea x *flava* = Catesbaei. *Macfarlane*, Wilmington, North Carolina, 1893; also *Macfarlane*, Holmes Co., Florida, and Baldwin Co., Alabama, 1905; *Bell*, Burgaw, North Carolina, 1947. Leaves similar in general shape to *S. purpurea* but longer, narrower; larger cordate erect hood. Flower intermediate red and yellow shaded together. Ponce de Leon, Holmes Co., Florida, *Macfarlane* (PENN 38475).

S. purpurea x *psittacina* = Courtii. Russell (1919) lists it as a reported natural hybrid but gives no further information or a description. Macfarlane (1908) never saw one growing wild. Cultivated in England, *Harrison* (US 2997).

S. purpurea x *Sledgei*. Russell (1919) reports it as grown in the University of Pennsylvania greenhouse, no further data. One plant collected near Theodore, Alabama, growing with its parents (*Bell 2-29*). Similar to the hybrid *S. Catesbaei*. Theodore, Mobile Co., Alabama, *Bell 542* (CNC).

S. purpurea x *rubra* = Chelsonii. Russell (1919) lists it as grown in University of Pennsylvania greenhouse, no further data. Wherry reported it collected in southeastern North Carolina, 1933. One plant from Scotland Co., North Carolina, collected in 1947 is growing in the University of North Carolina greenhouse. Leaves similar to *S. rubra*. Hood erect, larger than *rubra*, pitcher more expanded. Flower deep red, odorless. Sampson Co., North Carolina, *Wellman* (CNC). (Plate 13, fig. 6).

S. purpurea x *Drummondii* = Mitchelliana. *Macfarlane* (1908), Baldwin Co., Alabama, 1905. Also found by *Harper* (1918) in Walton Co., Florida, in 1911. Also *Bell* (*2-19*), Baldwin Co., Alabama, 1948. (First artificial hybrid, described

in England in 1887.) Leaf in general shape like that of *S. purpurea* but straighter and longer. Hood erect, cordate, undulate, white blotches, variegated red. Flower nodding, maroon. Theodore, Mobile Co., Alabama, *Bell* (CNC). (Plate 13, fig. 1).

S. Drummondii x *flava*=Moorei. Harper may have collected this in 1895 near Americus, Georgia, but identification was not positive. Macfarlane's plants found near Bay Minette, Alabama, in 1905 were cited by Harper. Pitchers similar to those of *S. flava* but hood undulate, white-blotched. Flowers intermediate rose and yellow. Crestview, Okaloosa Co., Florida, *Macfarlane* (PENN 15348, 49353, and 49354).

S. Drummondii x *Sledgei*=areolata. Russell (1919) from Mobile, Alabama, westward for thirty miles. *Wherry* (1935) same locality. *Bell* (*2-20*) west of Mobile, Alabama, 1948. Leaf similar to *S. Sledgei* but with white blotches at top. Hood slightly undulate. Flowers yellow-pink, intermediate. Theodore, Mobile Co., Alabama, *Macfarlane* (PENN 49329), also *Bell 542* (CNC).

S. Drummondii x *rubra*=Readi. Mentioned as the possible parentage of some plants collected by Harper (1918) near Americus, Georgia, in 1895 and 1901. No description. Listed by Russell (1919) but also without description. Herbarium specimen shows leaves to be intermediate in form and color. Deer Park, Washington Co., Alabama, *Reade* (PENN 57859).

S. minor x *flava*=crispata. *Harper* (1918), Bulloch Co., Georgia, 1901, and in Coffee Co., Georgia, 1902. *Macfarlane* (1908), Summerville, South Carolina. Pitchered leaves similar to *S. flava*, hood intermediate between parents. Douglas, Coffee Co., Georgia, *Harper 1437* (NY).

S. minor x *psittacina*=formosa. *Harper* (1918), Colquitt Co., Georgia, 1902, and Coffee, Irwin (now Ben Hill) and Wilcox counties in 1904. Harper (1918) states that this is the most free-flowering of the hybrids. Leaves decumbent, length intermediate, wing broad, intermediate, beaked hood like that of *S. psittacina*. Pitchers white-spotted as in *S. minor*. Fitzgerald, Irwin Co., Georgia, *Harper* (NY).

S. flava x *rubra*. *J. T. Harriot*, Carthage, North Carolina. No previous published report. Sepals tinged red, leaf intermediate between suspected parents. Carthage, Moore Co., North Carolina, *Harriot* (PH 815520).

S. rubra forma *jonesii* x *purpurea*. *Wherry* (1934) listed it as hybrid *S. jonesii* x *purpurea venosa*, undescribed. Mountains of North Carolina, 1932.

(*S. flava* x *purpurea*) x *flava*. *Macfarlane* (1908), Ponce de Leon, Florida, 1908. Pitchers like *S. flava* but flower shows traces of *S. purpurea*.

SUMMARY

The two genera of Sarraceniaceae under consideration are cytologically as well as morphologically distinct. The unreduced chromosome number for *Chrysamphora* (previously unreported) is thirty, while that of all members of the genus *Sarracenia* (previously unreported) is twenty-six. Within the latter genus chromosome morphology is of no value in interspecific differentiation. Morphological characteristics alone indicate, however, that a slight change in

previous taxonomic treatment is in order. *S. jonesii* is therefore reduced to the status of a form of *S. rubra*; the two subspecies of *S. purpurea* are consolidated and Fernald's form of this species, *heterophylla*, is reinstated.

During the investigation a previously unreported natural hybrid in the genus *Sarracenia* was found. Color photographs of intraspecific color differences in foliage were obtained for *S. flava* and *S. purpurea*.

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EXPLANATIONS OF PLATES

PLATE 8

Camera lucida drawings (3271×) and photomicrographs (1294×) of chromosomes in root-tip cells of:

1. *S. oreophila*
2. *S. flava*

3. *S. Sledgei*
4. *S. Drummondii*

PLATE 9

Camera lucida drawings (3271×) and photomicrographs (1294×) of chromosomes in root-tip cells of:

5. *S. rubra*
6. *S. minor*
7. *S. psittacina*
8. *S. purpurea*

Note: The genome shown of *S. rubra* contains the smallest chromosomes seen in any cell of any *Sarracenia* during this study. Those of *S. minor* are among the largest observed. Thus figures 4 and 5 represent extremes. Average chromosome length for *S. rubra* is 2.75 microns and for *S. minor* 2.86 microns—a difference of only .11 microns. The average chromosome lengths for all other species of *Sarracenia* fall between these two "extremes."

PLATE 10

Pollen-mother-cell smears from all species of *Sarracenia* showing reduced chromosome number. Camera lucida drawings 1367×, photomicrographs 809×.

PLATE 11

1. Petal outlines ½×) of all species of *Sarracenia*.
   1. *S. Sledgei*; 2. *S. rubra* forma *jonesii*; 3. *S. Drummondii*; 4. *S. rubra*; 5. *S. purpurea*; 6. *S. minor*; 7. *S. oreophila*; 8. *S. psittacina*; 9. *S. flava*.
2. Sepals of *S. purpurea*.
3. Sepals of *S. rubra* showing strong recurving.
4. Side and face view of leaves of *S. rubra*. ⅛×.
5. Side and face view of leaves of *S. rubra* forma *jonesii*. ⅛×.
6. Leaf comparison: *S. rubra* and *S. rubra* forma *jonesii* and intergrades, all ⅛×. Left to right:
   a. *S. rubra* forma *jonesii*
   b. *S. rubra* forma *jonesii*
   c. *S. rubra* (previously considered *jonesii* because of size)
   d. *S. rubra* forma *jonesii*
   e. *S. rubra* (intermediate)
   f. *S. rubra*
   g. *S rubra* (intermediate)
   h. *S. rubra*
   i. *S. rubra*
   j. *S. rubra*
   (a, b, d leaves from plant sent from Greenville, S. C. *Bell* 2–35; c leaf from plant collected at Deerland, Fla., *Bell* 2–15; all others from one clone of *S. rubra* collected in Moore Co., N. C., *Bell* 2–3. This entire series of leaves was pressed, *Bell 575* (CNC).

PLATE 12

Map of *S. rubra* and *S. rubra* forma *jonesii* distribution and probable range. •All marks are of cited specimens.

PLATE 13

1. *S. purpurea* × *Drummondii*-Mitchelliana, in greenhouse. Collected in Baldwin Co., Ala. March 1948. Some leaves and flower pressed, *Bell 548* (CNC).

2–3. Blooms of *S. Sledgei* showing recurving of petals. Collected in Mobile Co., Ala., March 1948. Bloomed in greenhouse.

4. *S. rubra* (*S. jonesii* Wherry) collected in Mobile Co., Ala. The shape of these leaves is identical with smaller plants of *S. rubra*, but because of its size the specimen was previously classified as *S. jonesii*.

5. *S. rubra* collected at Lakeview, Moore Co., N. C. Although the leaves are less than a foot tall they have somewhat of an "intermediate" appearance. *Bell 519* (CNC).

6. *S. purpurea* × *rubra*-Chelsonii. This plant was sent to Dr. W. C. Coker from Scotland Co., N. C. in 1947 by Mr. C. Wellman. It bloomed in the greenhouse in 1948. The flower and some leaves were pressed.

7. *S. purpurea* forma *heterophylla*. Collected at Young's Lake, Belle Isle, Annapolis Co., Nova Scotia. The yellow character of the leaves does not show in a photograph of this type, but the lack of red markings can be noticed.

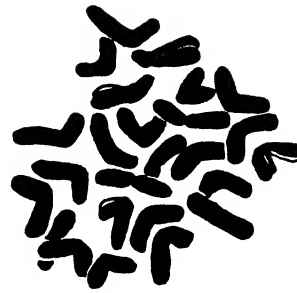
8. *S. rubra* forma *jonesii*. Plant growing in greenhouse. Note smaller typical *S. rubra* type leaves in the center of the picture.

PLATE 14

1. *Chrysamphora californica*. Photomicrograph of chromosomes in a root-tip section (1552×)
2. Camera lucida drawing (3925×) of material in 1 (above).
3. *Chrysamphora californica* growing in greenhouse.

PLATE 8

S. oreophila



1

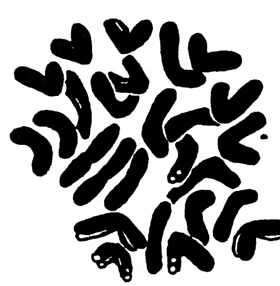
S. flava

2

S. Sledgei

3

S. Drummondii



4

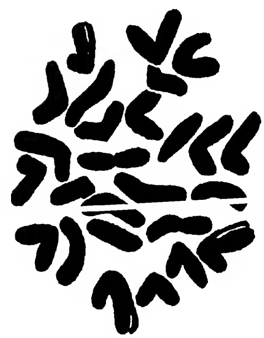
PLATE 9

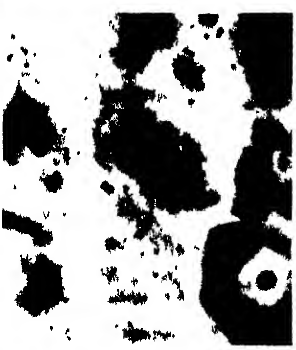
S. rubra

5

S. minor

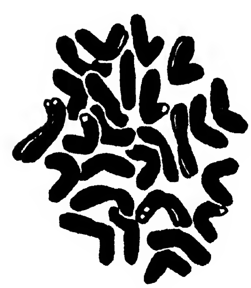
6





S. psittacina

7



S. purpurea

8

PLATE 10

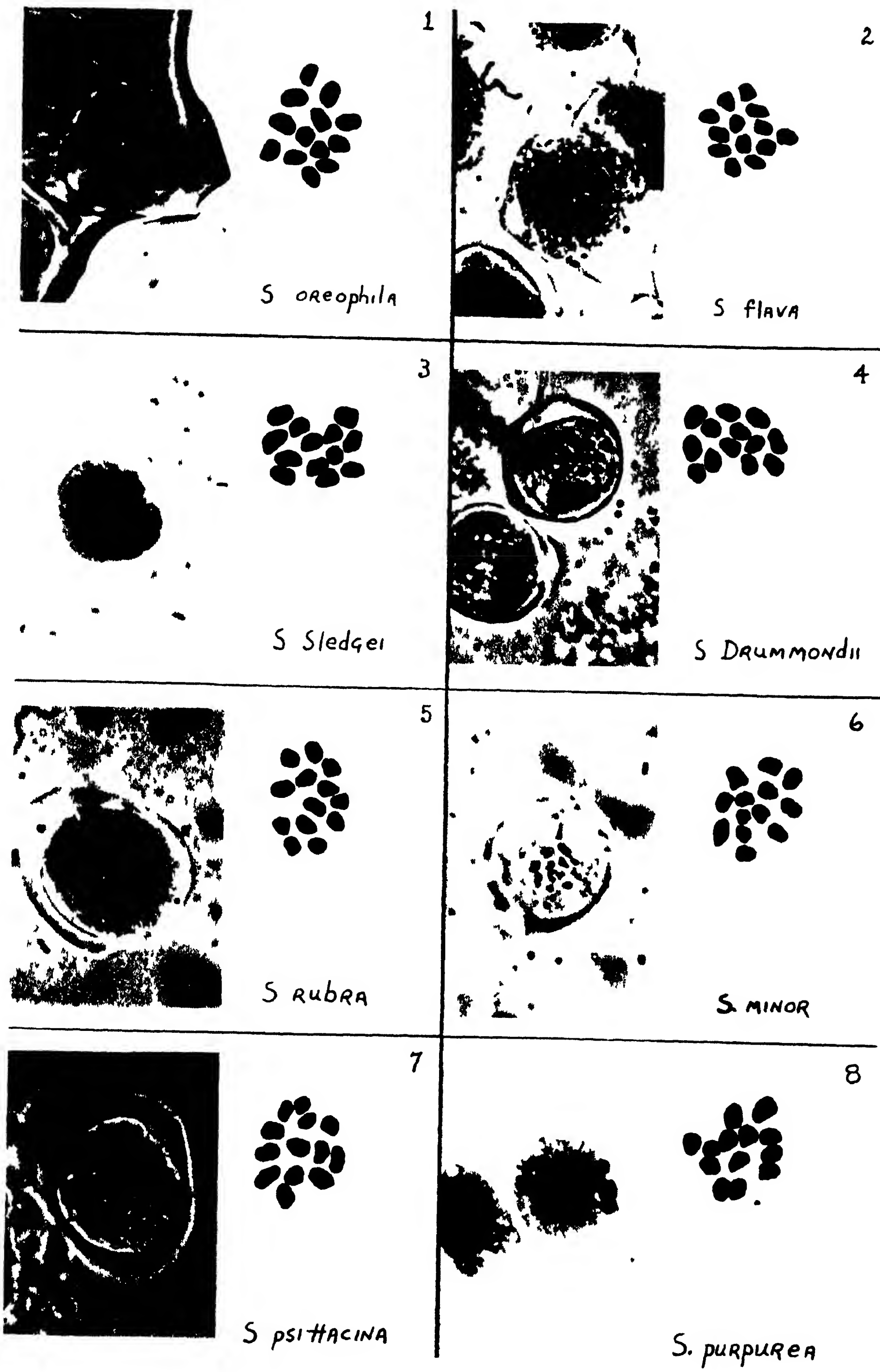
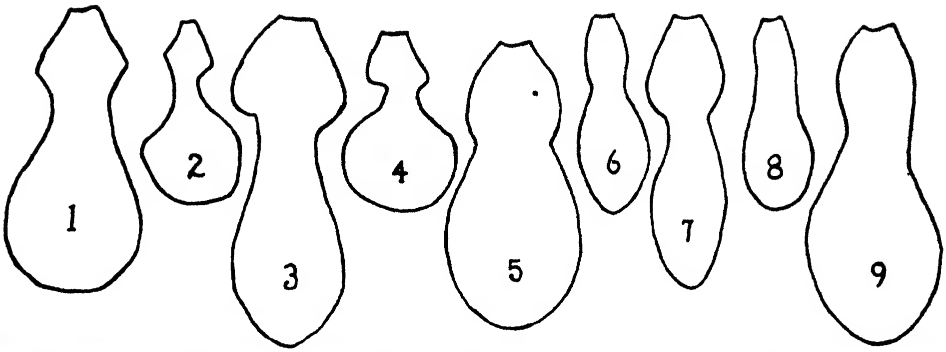

1
S oreophila
2
S flava
3
S Sledgei
4
S Drummondii
5
S rubra
6
S. minor
7
S psittacina
8
S. purpurea

PLATE 11



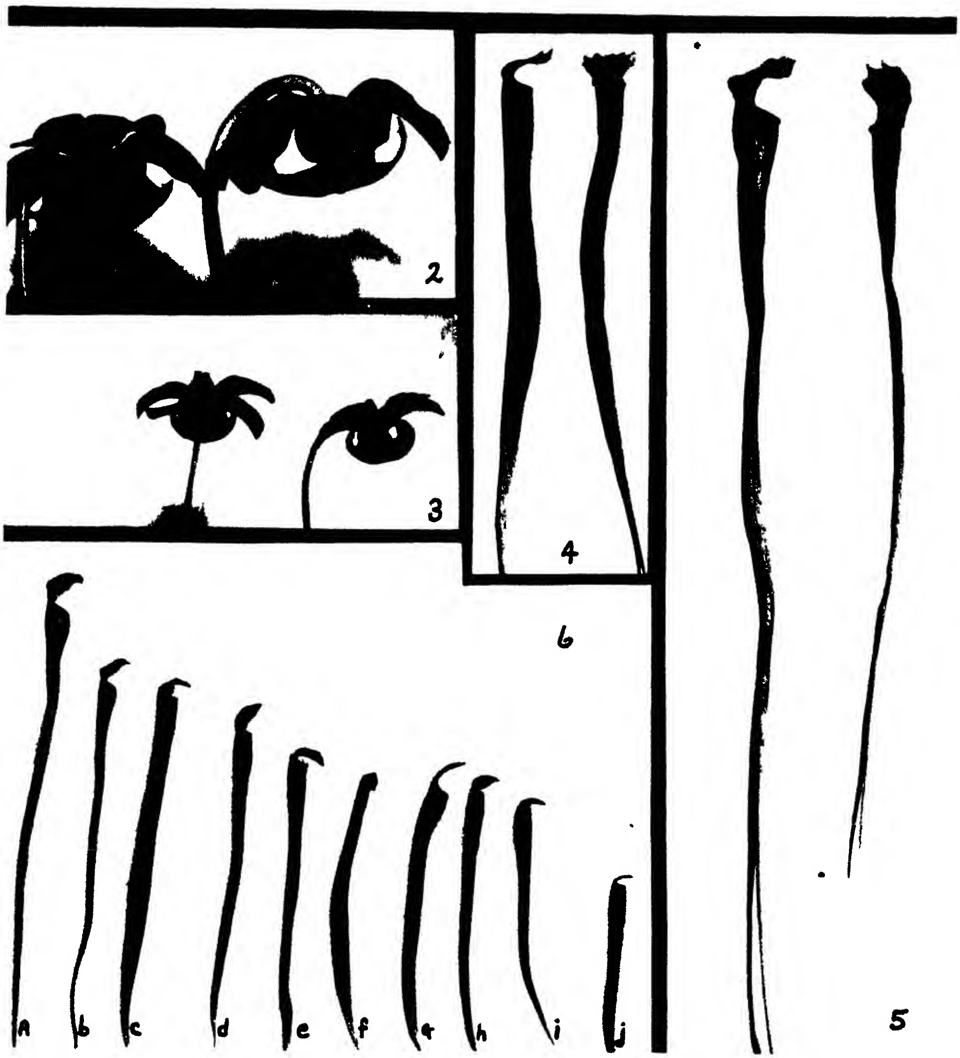


PLATE 12

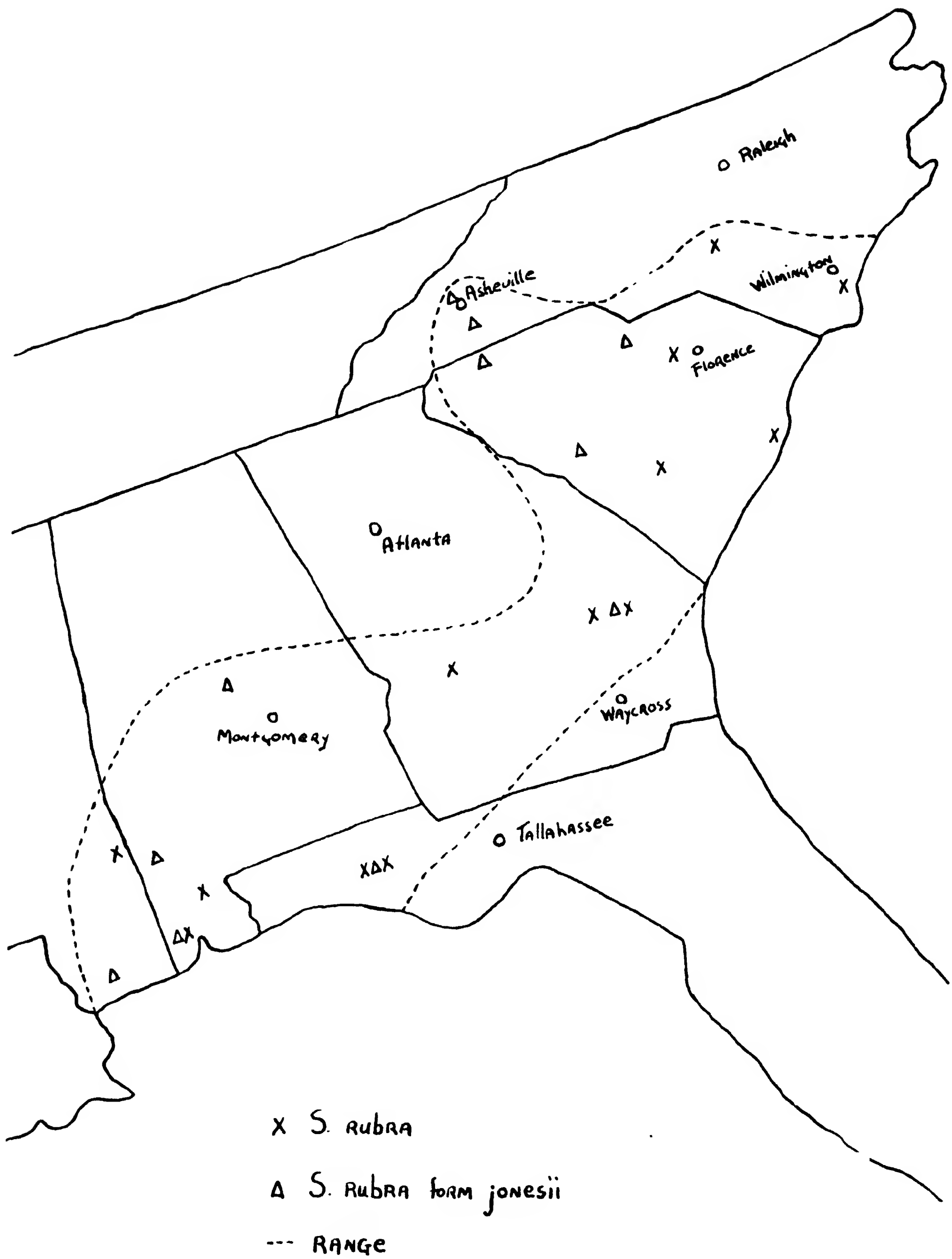
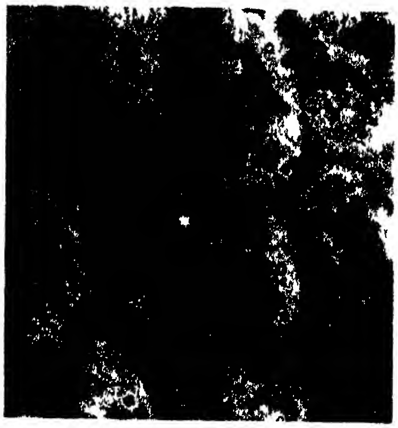
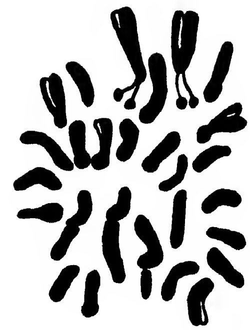

Raleigh
Asheville
Wilmington
Florence
Atlanta
Waycross
Montgomery
Tallahassee
X S. rubra
Δ S. rubra form jonesii
--- Range

PLATE 13

PLATE 14



1



2

JOURNAL

OF THE

Elisha Mitchell Scientific Society

Volume 65 | December 1949 | No. 2

PROCEEDINGS OF THE FORTY-SIXTH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE

UNIVERSITY OF NORTH CAROLINA, CHAPEL HILL, N. C.

The forty-sixth annual meeting of the North Carolina Academy of Science was held at the University of North Carolina on May 6 and 7, 1949.

The Academy convened in a general session at 10:00 a. m. on the first day with President O. C. Bradbury presiding. After the presentation of six papers the session adjourned at noon.

The afternoon session was called to order at two o'clock. After the reading of five papers the session closed and was followed by the business meeting.

The minutes of the 1948 meeting were approved as published in the Journal of the Elisha Mitchell Scientific Society **64**: 147–181. The reports of the various committees were then presented as follows:

REPORT OF THE EXECUTIVE COMMITTEE

The Executive Committee met in Durham, N. C., on May 5, 1949, and in Chapel Hill on May 6, 1949. At these meetings the following matters were transacted:

1. The Treasurer was authorized to spend up to $100.00 for secretarial aid.
2. The committee authorized the Treasurer to pay all outstanding bills for operating expenses and to submit his financial report as of July 1, 1949, to the auditing committee.
3. The following were elected to membership in the Academy:

Adkins, Dorothy C., Psychology, University of North Carolina
Anderton, Laura G., Biology, Woman's College U. N. C.
Antonakos, Nicholas, Botany, University of North Carolina
Ardrey, Margaret Martin, Science, Guilford High School
Atchison, Earlene, Botany, University of North Carolina
Barringer, Thomas Smith, Catawba College
Basham, Janet Brooks, Psychology, Duke University
Bell, Clyde Ritchie, Botany, University of North Carolina
Birge, William Root, Psychology, Duke University
Black, Clarence Sigler, Jr., Entomology, N. C. State College

Blanton, Sankey Lee, Jr., Geology, University of North Carolina
Boyce, Steve Gaddy, Forestry, N. C. State College
Boyd, Elizabeth, Mathematics, Greensboro College
Broadhurst, Sam Davis, Geology, N. C. Department of Conservation and Development
Browne, Edward Tankard, Jr., Botany, University of North Carolina
Cohen, Louis David, Psychology, Duke University
Colvin, Ralph Whitmore, Psychology, Duke University
Cook, James William, Elon College
Cooper, William Earl, Plant Pathology, N. C. State College
Costello, Donald Paul, Zoology, University of North Carolina
Cox, Benjamin Franklin, Poultry, N. C. State College
Craig, Frank Rankin, Poultry, N. C. State College
Dai, Bingham, Psychiatry and Psychology, Duke School of Medicine
Deal, Glenn William, Science, China Grove High School
Eller, Frank W., Charlotte College Center
Ellison, William Andrew, U. N. C. Fisheries Research Institute, Morehead City
Evers, John Lawrence, Zoology, N. C. State College
Field, Mrs. Henry R., Science, Gray High School, Winston-Salem
French, R. Carson, Chemistry, Salem College
Galloway, Carl Wilson, Horticulture, N. C. State College
Getzen, James H., Wake Forest College
Glazener, Edward Walker, Poultry, N. C. State College
Gminder, Russell, Catawba College
Gordon, Hiram Landor, Psychology, Duke University
Gordon, Morris Aaron, Botany, Duke University
Hackney, Edward June, Chemistry, Duke University
Hall, William Gardner, Catawba College
Hamilton, Dorothy Elizabeth, Psychology, N. C. Department of Public Welfare
Hammons, Ray O., Agronomy, N. C. State College
Hamrick, Marietta, Biology, Gardner-Webb Junior College
Harpster, Hilda T., Biology, Woman's College U. N. C.
Heck, Landon Carroll, Physics, Catawba College
Hester, William, Psychology, Duke University
Hoke, Owen Heller, Mathematics, University of North Carolina
Hudson, A. E. A., Biochemistry, N. C. State College
Jenkins, Charles Ross, Jr., Psychology, Duke University
Jones, Ora Melinda, Psychology, Duke University
Keever, Nancy Catherine, Botany, Duke University
Kirk, D. E., Botany, University of North Carolina
Klemm, Ethel Mina, Science, Warren Wilson College
Lancaster, Eloise, Agronomy, N. C. State College
Lehman, H. Eugene, Zoology, University of North Carolina
McKeever, Sturgis, Zoology, N. C. State College
McKinley, Glenn Ernest, Geology, N. C. State College
Macon, Nathaniel, Mathematics, University of North Carolina
Marshall, Roy K., Astronomy, University of North Carolina
Miller, Harry Brown, Chemistry, Wake Forest College
Miller, William Knight, Chemistry, University of North Carolina
Nowell, John William, Chemistry, Wake Forest College
O'Connell, J. Elbert, Biology, Wake Forest College
Osborne, Elizabeth M., Biology, Woman's College U. N. C.
Pack, Albert Boyd, Botany, N. C. State College
Pendergrass, William R., Botany, University of North Carolina
Pope, Hilda Persons, Bacteriology, Duke School of Medicine

Powell, William Allen, Chemistry, Wake Forest College
Rice, Lucile Addie, Biology, East Carolina Teachers College
Robinson, Joe, Elon College
Rodgers, Charles L., Botany, University of North Carolina
Roe, Arthur, Chemistry, University of North Carolina
Schuler, Anne Warren, Physics, Woman's College U. N. C.
Schulz, Henry Louis, Liggett and Myers Tobacco Co., Durham
Stinetorf, Roscoe, Mathematics, Catawba College
Thomas, Annabelle, Biology, Woman's College U. N. C.
Thompson, Anne Elizabeth, Entomology, N. C. State College
Townes, Henry K. Jr., Entomology, N. C. State College
Townes, Marjorie Chapman, Raleigh
Trott, John, Jr., Children's Nature Museum, Charlotte
Tucker, Irwin William, Liggett and Myers Tobacco Co., Durham
Turkel, Henry, Physician, Detroit, Michigan
Wheeler, Robert James, Jr., Wildlife Resources Commission, Raleigh
Williams, J. Paul, Chemistry, University of North Carolina
Williams, Ruth Margaret, Psychology, Duke University
Wright, Paul Gordon, Biology, Wilmington College
York, M. A., Raleigh
Yost, Basil Otto, Elon College
Youngs, Lillian Margot, Biology, Catawba College

4. The following were reinstated as members in the Academy:

Brannon, Clarence H., Entomology, N. C. State Department of Agriculture
Coldwell, E. Inez, Biology, Woman's College U. N. C.
Crockford, Horace Downs, Chemistry, University of North Carolina
Ferguson, John Howard, Physiology, University of North Carolina School of Medicine
George, Wesley Critz, Anatomy, University of North Carolina School of Medicine
Love, Lila Belle, Biology, Woman's College U. N. C.
Miller, Edwin Lawrence, Jr., Geology, N. C. State College
Parker, John Mason III, Geology, N. C. State College

5. The Secretary reported the following losses in membership:

1. By resignation: 2
2. By non-payment of dues: 18
3. By death the following:
   William John Dann
   Albert Harvey Grimshaw
   Harvey Burnell Ohmer
   William Wilson

6. The Committee accepted the invitation of the Woman's College of the University of North Carolina to meet in Greensboro in 1950.

The above reports of the Executive Committee were adopted by the Academy.

TREASURER'S REPORT

Financial Statement as of July 1, 1949

Receipts

Bank balance (from July 1, 1949)	$65.92
Gift	
A. A. A. S. Research Grant, 1949	74.50

Dues, 1948	9.00
Dues, 1949	538.00
Dues, new members and reinstatements	186.00
Total	873.42
Expenditures	
Elisha Mitchell Scientific Society	300.00
Secretarial aid	80.00
W. B. Fox and R. K. Godfrey (A. A A S Research Grant)	74.50
Secretarial commission	70.00
Stationery, printing and programs (N. C. State Print Shop)	50.55
Postage and stamped envelopes	49.96
Academy Awards	25.00
Waverly Press (reprints)	14.70
A. D. Shaftesbury (postage, High School Committee)	14.50
Piedmont Press (printing, High School Committee)	8 50
Bank charges	4 34
Expenses to meeting	3 00
Office supplies	2 73
Total	607 78
Bank balance	173 64
Cash on hand	2.00
	873 42

Savings Account

Balance July 1, 1949	66 53

Total Assets

Checking account and cash on hand	175 64
Savings account	66 53
U S. Savings Bonds (maturity value)	300 00
Total	542 17

On the first day of July, 1949, we, the undersigned, have examined this account and found it to be correct.

(Signed) F. S. BARKALOW, JR
BEN W. SMITH
J. M. CLARKSON, *Chairman*

REPORT OF THE LIFE MEMBERSHIP COMMITTEE

The committee, consisting of G. H. Satterfield, J. N. Couch, Maude Williams, and H. J. Oosting, in accordance with the rules governing life membership which were established in 1943, recommended that the following persons be elected to life membership:

Hugo Leander Blomquist, Botany, Duke University
John Paul Givler, Biology, Woman's College U. N. C.
William Woodrow Martin, Psychology, Woman's College U. N. C

The Academy unanimously elected these scientists to life membership.

REPORT OF THE RESEARCH GRANTS COMMITTEE

The award for the past year was given to Dr. E. C. Cocke of Wake Forest in support of his survey of the Myxophyceae of North Carolina. The committee, now consisting of O. C. Bradbury, B. W. Wells, W. O. Puckett, and A. D. Shaftesbury, received three applications for the 1949 A. A. A. S. grant. After due consideration it was decided to present the grant to Dr. W. B. Fox and Mr. R. K. Godfrey of N. C. State College. They will use the grant of $74.50 for partial defrayment of expenses incurred in a study of the Leguminosae and Compositae of North Carolina.

E. C. COCKE
G. R. MACCARTHY
W. O. PUCKETT
B. W. WELLS, *Chairman.*

REPORT OF THE POTEAT AWARD COMMITTEE

The committee met at noon on Saturday, May 7, 1949, and discussed at length the difficult problem of selecting a meritorious paper presented this year. After due consideration it was decided to grant the award to Miss Nancy Catherine Keever for her excellent paper, "Causes of succession on abandoned fields in the Piedmont of North Carolina."

K. L. BARKLEY
D. S. GROSCH
W. L. HAMNETT
REINARD HARKEMA
H. V. PARK
MARY E. YARBROUGH
LEWIS E. ANDERSON, *Chairman.*

REPORT OF THE HIGH SCHOOL SCIENCE COMMITTEE

Dr. A. D. Shaftesbury, Chairman of the committee, informed the Academy that no essays were received to compete for the Ornithology and Forestry Awards. Announcement was made at the evening meeting of the following winners of exhibit awards:

THE ACADEMY AWARD

First Prize: Henry Yancey, Central High School, Charlotte; Frank W. Eller, Sponsor.
"Water Purification."

Second Prize: David Sims, Central High School, Charlotte; Frank W. Eller, Sponsor.
"Materials for Electromagnetic Radiation."

Third Prize: Roderick Reid, Central High School, Charlotte; Frank W. Eller, Sponsor.
"Rockets."

BIOLOGICAL EXHIBITS AWARD

(Carolina Biological Supply Company)

First Prize: Dave Adams, Central High School, Charlotte; Frank W. Eller, Sponsor.
"Representative Mammals."

Second Prize: Tenth Grade Biology Class, Black Creek High School; Mrs. Will Rhodes, Sponsor.
"Biology Exhibit."

Third Place: Tommy Thompson, New Hanover High School, Wilmington; P. G. Wright, Sponsor.
"Preserved Specimens."

REPORT OF THE CONSERVATION COMMITTEE

Last year the Committee reported on the forestry situation in North Carolina. The report was dressed up by Dr. W. Amos Abrams, Associate Editor of *North Carolina Education,* under the catchy title "Our Forest Follies," and together with a photograph was published in that journal. This periodical reaches most of the teachers in the State. One thousand reprints of the report were obtained and requests quickly exhausted the supply, except for a few copies which were withheld.

This year we are submitting a report on the North Carolina resource-use education program. The Academy members are somewhat familiar with the character of the program in that the program director has given papers at the last two annual meetings.

The program has been sponsored by the North Carolina Resource-Use Education Commission which was appointed by the Governor in 1948. It is composed of representatives of 46 state agencies, professional, scientific, and educational organizations. Dr. F. G. Hall, our past President, represents the Academy on the commission. The program Director, Dr. Richard Weaver, has been employed by the Commission since February 1947, with headquarters here in Chapel Hill on funds supplied by the General Education Board. As of July 1 this year, Dr. Weaver will become a member of the staff of the State Department of Public Instruction with headquarters in Raleigh. A consultant in resource-use education, Mr. Homer Lassiter, has also been added to the staff as of May 1 through a special contract with the Tennessee Valley Authority.

The Commission was organized and the staff was charged with the responsibility for:

(1) Channeling more scientific information about resources into the school program.
(2) Making greater use of the resource agencies, materials, and staff in the educational program of the State.
(3) Developing projects and plans which would help teachers and colleges make education deal more directly with the problem of living, the development of communities, and the sound management of resources.

Eight area centers were organized at the following institutions:

Appalachian State Teachers College, Boone, N. C.—Chairman, Julian C. Yoder
East Carolina Teachers College, Greenville, N. C.—Chairman, Leo W. Jenkins
Elizabeth City State Teachers College, Elizabeth City, N. C.—Chairman, President S. D. Williams
North Carolina College, Durham, N. C.—Chairman, Theodore R. Speigner
Shaw University, Raleigh, N. C.—Chairman, President Robert P. Daniel
Saint Augustine College, Raleigh, N. C.—Chairman, President Harold L. Trigg
Western Carolina Teacher's College, Cullowhee, N. C.—Chairman, W. B. Harrill
Woman's College, University of North Carolina, Greensboro, N. C.—Chairman, Dennis H. Cooke

A faculty committee, an area committee composed of representatives of resource agencies and the public schools in the area, developed programs and projects for each area. Ten or more schools in each area agreed to be participating schools to develop special resource-use programs.

Area conferences and summer workshops have been held at these centers where school people have worked with scientists and resource technicians to determine what information about resources should be included in the school program, and which techniques are most successful. Two hundred fifty teachers were enrolled in five resource-education workshops held last summer at Boone, Greensboro, Greenville, Cullowhee, and Brasstown.

This year workshops will be held at Boone, Greenville, Elizabeth City, Salisbury (Catawba College), and at Raleigh where North Carolina College, Shaw University and Saint Augustine's College are cooperatively sponsoring one workshop on the campus of Saint Augustine's.

A Guide on Resource-Use and a State Directory of Resource Agencies is nearly completed, which will assist teachers, college staff members and others in developing a greater emphasis on the use, conservation, and management of all of our resources.

Special guides on forestry, wildlife, agriculture, soil conservation, minerals and geology, water, and industry are being considered by the various State agencies responsible for these resources.

Films, radio programs, and demonstrations are needed and will be provided as rapidly as possible.

Academy members can assist in the expansion of this important program in many ways such as:

(1) More emphasis is needed in all the colleges and in most of the science courses on the development and wise use of our resources, particularly those in which future teachers are enrolled. These teachers need to know more about the wealth of resources in North Carolina, the ways to manage and develop these resources, the best techniques for studying them, the sources of information, and help through the state and federal agencies and private organizations.

Field trips, contact with resource personnel, individual field research and observation, greater use of visual materials and local data are some of the ways this instruction can be made more effective.

(2) Organization of resource-use workshops on campuses for teachers and undergraduates where information on each of the resources is available, but also

where the interrelation and interdependence of the plants and animals, soils, water, and minerals can be illustrated, and where the development of these can be oriented toward the improvement of living, the raising of the economic level, the greater provision for food, shelter, clothing, recreation, and the cultural needs of people.

(3) Make yourself available to city and county school systems and the resource-use area centers for consultant help to discuss the results of your research, and to advise on the special problems of resource management in your special interest field.

(4) Help popularize the new research findings through articles for educational journals and talks to adult groups.

(5) Assist in the practical research needed in those fields where communities need special help, such as combating stream pollution, development of parks, scenic areas, wildlife sanctuaries, demonstration areas, interesting new types of industries in your city or town, developing new markets and products for the maximum use of the resources in your region.

Conclusions

While teaching the principles of science and engaging in scientific research we should endeavor to seek out and stress the practical applications so that North Carolina with its wealth of natural resources, people, agencies and institutions can provide a richer, fuller and more abundant life for all its people.

The Academy of Science, through its members, can provide the leadership and initiative at the various educational centers to develop a greater emphasis on resource-use education and to help in the important job of training our future teachers in the values and techniques of wise resource management and use.

ARTHUR STUPKA
R. L. WEAVER
C. F. KORSTIAN, *Chairman.*

The above report was approved by the Academy.

REPORT OF THE LEGISLATIVE COMMITTEE

Nothing was brought to the attention of the Legislative Committee during this year. Several persons were contacted to discover if any matters should be looked into, but there were none.

B. W. WELLS
H. F. PRYTHERCH
Z. P. METCALF, *Chairman.*

The above report was accepted as information by the Academy.

REPORT OF THE RESOLUTIONS COMMITTEE

Be it resolved that the North Carolina Academy of Science is deeply appreciative of the hospitality, entertainment, and courtesies extended to its members by

Chancellor R. B. House, the Faculty, and students of the University of North Carolina; and that the especial appreciation of the Academy is due the local Committee on Arrangements for its part in making this, its forty-sixth annual meeting, successful and enjoyable.

Be it further resolved that a copy of this resolution become a part of the minutes of the Academy, and that copies be sent to Chancellor R. B. House and to Dr. J. N. Couch, Chairman of Committee on Arrangements.

O. J. THIES.

The above resolution was unanimously approved by the Academy.

REPORT OF THE SPECIAL COMMITTEE ON THE JOHN BEWLEY DERIEUX MEMORIAL AWARD

Whereas, Mrs. Elizabeth Tipton Derieux has expressed the wish to establish within the North Carolina Academy of Science a memorial to her late husband, Dr. John Bewley Derieux, in the form of an annual award for the best essay submitted by a college student on a topic in the field of Modern (or Contemporary) Physics, be it resolved:

First, that the Academy gratefully accept the offer to establish this memorial award as a fitting tribute to the long period of faithful service to the Academy and the active interest which Dr. Derieux displayed at all times in the activities of the Academy.

Second, that the award be known as the John Bewley Derieux Memorial Award.

Third, that this Award be included as an annual activity of the Academy for the purpose of stimulating interest among college students in pursuing further study in this field of learning.

Fourth, that, in accordance with the wishes of the donor, the Award be fifty dollars in cash and an inscribed certificate of the Award for the best essay by a North Carolina college student on a topic in the field of Modern (or Contemporary) Physics.

Fifth, that these resolutions be made a part of the minutes of the Academy, that the Secretary of the Academy supply the press of the State with notice of the establishment of the Award, and that a copy of these resolutions be transmitted to the donor of the Award.

W. E. SPEAS
OTTO STUHLMAN, JR.
J. S. MEARES, *Chairman.*

The above report was unanimously approved by the Academy

PART II

To activate the John Bewley Memorial Award the Committee makes the following recommendations:

1. That the President of the Academy annually appoint a committee to judge the essays and report the name of the award winner to the Academy at its annual meeting.
2. That the Secretary of the Academy be responsible for implementing the Award by giving due publicity in the colleges, in the State of North Carolina, concerning the Award by October first of each year.
3. That an eligible participant be any regularly enrolled undergraduate student in any college or university in North Carolina.
4. That the essay may have any specific title within the general area currently referred to as Modern Physics (or, the general area of contemporary developments in Physics during the past ten years).
5. That the essay be typewritten on $8\frac{1}{2}'' \times 11''$ size paper, double-spaced, with one-inch margins, and not exceeding 3,000 words in length (excluding illustrative material).
6. That the local college staff, in the departments of origin of the essays, examine the entries of its students and submit not more than the best two essays to the Secretary of the Academy at least six weeks prior to the annual meeting of the Academy.
7. That in competing for this Award the candidate accepts the recommendation of the judging committee as final.
8. That the judging committee be empowered to recommend that no award be made in any year when the members unanimously agree that no entry meets a reasonable standard of excellence worthy of the Award.
9. That the Secretary of the Academy be responsible for issuing the engraved

Certificate of Award in cooperation with the Donor. The Donor agrees to assist in the design of the certificate and to finance its engraving.

W. E. SPEAS
OTTO STUHLMAN, JR.
J. S. MEARES, *Chairman.*

The above recommendations were accepted by the Academy.

The following memorial reports were presented at the meeting:

WILLIAM JOHN DANN

Dr. William John Dann was born in Bath, England, November 9, 1904. He received the B.S. degree from the University of Sheffield in 1925 and the Ph.D. degree from Cambridge University in 1932, where he received training from Sir Frederick Gowland Hopkins, internationally known scientist and Nobel laureate. Dr. Dann was awarded the Doctor of Science degree in 1943 by his alma mater, the University of Sheffield, a very high honor. Dr. Dann came to Duke University in 1934 as a Beit Memorial Fellow. He was appointed assistant professor and subsequently associate professor and in 1945 professor of nutrition in the Medical School of Duke University. He died on December 5, 1948, after an illness of several months.

Dr. Dann exerted a forceful influence in the field of nutrition. He was a true experimentalist with a clear and precise mind. His earlier contributions dealt with the physiology of vitamin A, especially as related to placental transfer. His later researches were in the field of niacin in foods. He described many methods for vitamin determinations and under his editorship the very valuable symposium "Estimation of Vitamins" was published. He served for many years on the editorial staff of the Nutrition Reviews.

John Dann was a modest man who profoundly influenced his associates. He encouraged frank and honest discussion. He was at times impatient with confused and emotional thinking, but he was always generous. He held to liberal views and was acutely aware of the social responsibilities of science and of nutrition in particular.

Our science is poorer because of the loss of W. J. Dann. The North Carolina Academy of Science will miss this steadfast scientific leader. His associates at Duke University are greatly saddened by the departure of so true and noble a friend.

F. G. HALL.

The above memorial was approved by a rising vote.

ALBERT HARVEY GRIMSHAW

Professor Albert Harvey Grimshaw, member of the faculty of the School of Textiles at North Carolina State College for 24 years, died in Raleigh on April 20 following a period of ill health, but as the immediate result of a heart attack.

A native of Providence, Rhode Island, he received his undergraduate education at the Textile Institute of New Bedford, Massachusetts, and North Carolina State College. He received the Bachelor of Science degree from State College in 1927 and the Master of Science degree in 1935. He also attended the Massachusetts Institute of Technology and Columbia University for special training. He was a registered pharmacist, and operated a pharmacy in New Bedford from 1916 to 1925, and for a part of that time acted as head of the Department of Chemistry and Dyeing at the Textile Institute.

He came to North Carolina State College in 1925, and was head of the Department of Chemistry and Dyeing for many years, retiring from that position several months ago. He was active in research in the field of textiles and was a very prolific writer, contributing to most of the textile journals in this country.

In addition to his affiliation with the North Carolina Academy of Science he was a member of the American Association for the Advancement of Science, the American Institute of Chemists, and the American Association of Textile Chemists and Colorists. He was a member of Phi Kappa Phi, Sigma Tau Sigma, Delta Kappa Phi and Gamma Sigma Epsilon. The State College chapter of Gamma Sigma Epsilon recently presented a portrait of him to the College, where it now hangs in the School of Textiles.

He is survived by his widow, by a son, Dr. Albert Grimshaw of the University of Illinois, a sister, Miss Margaret Grimshaw of Somerville, Massachusetts, a brother, Mr. Ralph Grimshaw, of Cleveland, Ohio, two grandchildren and one great grandchild.

T. B. MITCHELL.

The above memorial was approved by a rising vote.

HARVEY BURNELL OHMER

Mr. Harvey Burnell Ohmer, member of the North Carolina State College faculty, died in Baltimore, June 26, 1948, after a short illness.

He was born February 10, 1910, in St. Clair County, Michigan, near the town of Yale, and was educated at Yale Public Schools, Port Huron Junior College, and Michigan State College, where he received his B.S. degree in Chemistry in 1934. Having been awarded a fellowship in chemistry he returned to Michigan State College for the following two years and obtained his M.S. degree in 1936, in the fields of biological chemistry and bacteriology. From 1936 to 1942, he was in charge of chemistry at Port Huron High School, Port Huron, Michigan. The summers from 1937 to 1941 were spent in bacteriological research at Faison, North Carolina, on commercial cucumber fermentations in connection with the cooperative project between the North Carolina Agricultural Experiment Station, the U. S. Department of Agriculture, and the Chas. F. Cates Company. It was in this capacity that he made important contributions to the research program in commercial brine fermentations and development of the pasteurization procedure now so widely used in the pickling industry.

From 1942 to 1946, he served in the U. S. Army as a First Lieutenant in the

Chemical Warfare Service, and taught toxicology at Edgewood Arsenal. For two years he was in charge of the Toxicological Research Laboratory. Mr. Ohmer came to North Carolina State College in 1946, and was a member of the Chemistry Department until his untimely death. In the brief period of two years, he earned a reputation as an outstanding teacher; one who enjoyed teaching and the opportunity to work with students. He had that rare gift of human understanding, and it could be said that helping others was his hobby. In addition to his teaching duties, he had completed most of the requirements for his doctorate. Just a few days before his death he had isolated a number of cultures of halophilic bacteria responsible for a new type of gaseous fermentation in cucumber brines.

He was a member of the Society of American Bacteriologists, North Carolina Society of Bacteriologists, Alpha Chi Sigma, professional chemical fraternity, Sigma Alpha Beta, honorary bacteriological fraternity, and the North Carolina Academy of Science. His church affiliation was with the First Presbyterian Church, Raleigh, North Carolina.

Surviving are his widow, Mrs. Helen Taylor Ohmer of Raleigh, North Carolina, two brothers and two sisters: Charles of Yale, Michigan, and Henry of Saginaw, Michigan, Mrs. Timothy Cook of Yale and Mrs. Holland Whitney of St. Louis, Michigan.

T. A BELL
J. L. ETCHELL
G. H. SATTERFIELD.

The above memorial was approved by a rising vote.

WILLIAM WILSON

William Wilson, Professor of Physics at North Carolina State College, died at Rex Hospital in Raleigh on May 6, 1948. He is survived by his wife, the former Ada M. Edlin, and three sons: William, David, and Stephen Wilson.

Dr. Wilson was born at Preston, England, March 29, 1887, and attended the public schools there. He studied under the great Lord Rutherford at the University of Manchester in England, from which he received the B.Sc. degree in 1907, the M.Sc. degree in 1908, and was awarded the D.Sc from this institution in 1913. In the meantime, he did research under the eminent physicist Sir J. J. Thompson at Cambridge University from which he received the B.A. degree in research in 1912. During the above period he published numerous papers in the field of radioactivity, the more important results of which are given in Rutherford's book, "Radioactive Substances and their Radiations."

In 1912 Dr. Wilson came to Canada as Lecturer in Physics at the University of Toronto, where he remained until 1914. From 1914 to 1942 he was with the Research Department of the Western Electric Company and the Bell Telephone Laboratories in New York. During this period he held a number of important positions with the Laboratories such as: Assistant Director of Research, Director of Vacuum Tube Research, Director of Radio Research, Director of Wire

Transmission Research, and Assistant Vice-President of the Laboratories. While at the Laboratories he published a number of papers in the field of radio and wire telephony. He was a Fellow of the American Physical Society, the American Institute of Electrical Engineers, the American Association for the Advancement of Science, the Institute of Radio Engineers, and a member of the Union Scientifique International de Radio. He served on many important committees, both national and international, of the various societies with which he was affiliated. In 1943 the Institute of Radio Engineers conferred on him one of its highest awards, the Medal of Honor.

Due to a heart ailment Dr. Wilson retired from the Bell Laboratories in 1942, but after a rest of two years returned to the teaching profession. He was at the Phillips Exeter Academy from 1944 to 1946. In September, 1946, he joined the Physics Department Staff at State College and during the year became a member of the North Carolina Academy of Science.

During his relatively short period of service in North Carolina Dr. Wilson won the deep respect and admiration of his associates and students through his warm personality, scholarly attainments, broad interests, and human understanding. We wish hereby to express our deep feeling of loss in the passing of this able adviser, scholar, and friend.

J. S. MEARES.

The above memorial was approved by a rising vote.

REPORT OF THE NOMINATING COMMITTEE

The Committee, consisting of M. L. Braun, Chairman, H. L. Blomquist, and R. E. Coker, submitted the following nominations:

President: C. F. Korstian, Duke University

Vice-President: W. O. Puckett, Davidson College

Secretary-Treasurer (3 years): Reinard Harkema, N. C. State College

Member of the Executive Committee: C. H. Bostian, N. C. State College

Member of the Research Grants Committee: A. D. Shaftesbury, Woman's College U. N. C.

There being no nominations from the floor, the Secretary was asked to cast the ballot and declare the nominees elected. This concluded the business and the meeting was adjourned.

At 6:00 p.m. the membership enjoyed a complimentary dinner given by the University of North Carolina. Vice-president P. J. Kramer presented Chancellor R. B. House of the University of North Carolina, who welcomed the Academy to the Campus. At 8:00 p. m. the evening session was held in Gerrard Hall. After announcing the winners of the High School Awards, Dr. P. J. Kramer presented the President of the Academy, Dr. O. C. Bradbury. Dr. Bradbury's Presidential Address was entitled, "Some Ecological Phases of a Prairie Region with Special Reference to Insect Ecology."

All of the sectional meetings were held on Saturday morning. These were well attended. The following officers were elected for the respective sections:

Biochemistry and Physiology: Chairman, G. C. Kyker; Secretary, Marjorie Swanson.
Botany: Chairman, L. A. Whitford; Secretary, L. E. Anderson.
Geology: Chairman, H. T. Davis; Secretary, E. W. Berry.
Mathematics: Chairman, Whitfield Cobb; Secretary, A. V. Coble.
Psychology: Chairman, Karl Zener; Secretary, Marion Stanland.
Wildlife: Chairman, T. L. Quay; Secretary, W. L. Hamnett.
Zoology: Chairman, A. D. Shaftesbury; Secretary, D. S. Grosch.

The following constitute the personnel of the standing committees:

Executive: C. F. Korstian, W. O. Puckett, Reinard Harkema, I. E. Gray, A. F. Thiel, C. H. Bostian.
Research Grants: O. C. Bradbury, B. W. Wells, W. O. Puckett, A. D. Shaftesbury.

Dr. C. F. Korstian, President of the Academy for 1950, announced the appointment of the following committees:

Auditing: J. M. Clarkson, B. W. Smith, F. S. Barkalow, Jr.
Conservation: R. L. Weaver, F. S. Barkalow, Jr., W. D. Miller, H. J. Oosting.
High School: Ruth M. Addoms, J. H. Highsmith, M. W. Johnson, H. S. Roberts, Jr., Ruby Williams.
Legislative: F. G. Hall, J. L. Stuckey, H. L. Blomquist.
Life Membership: J. N. Couch, Maude Williams, W. L. Porter.
Nominating: O. C. Bradbury, M. L. Braun, F. G. Hall.
Poteat Award: L. E. Anderson, E. W. Berry, A. V. Coble, D. S. Grosch, W. L. Hamnett, Reinard Harkema, Marion Stanland, Marjorie Swanson.
Resolutions: E. T. Browne.
Representative on A. A. A. S. Council: John N. Couch.
Representative to Academy Conference: Reinard Harkema.
Constitution: H. R. Totten, H. L. Blomquist, Reinard Harkema.

Approximately 400 members and guests registered during the meeting.

The following papers were presented during the meeting. Those marked with an x are abstracted in these proceedings.

GENERAL SESSIONS

Address of Welcome. Chancellor R. B. HOUSE, University of North Carolina.
Presidential Address: Some ecological phases of a prairie region with special reference to insect ecology. O. C. BRADBURY, Wake Forest.
x*Origin of the Carolina Bays: Evidence from some peat profiles.* B. W. WELLS, N. C. State.
Effect of 2,4-D compounds on some aquatic plants. L. A. WHITFORD, N. C. State.
x*Bioelectric potential transients accompanying closing movements of the lobes of Venus' fly-trap.* OTTO STUHLMAN, JR., and E. B. DARDEN, U. N. C.
Notes on type localities for Polycodium *and some cytological findings.* B. E. SMITH Wake Forest.

The effect of chemical control of suckering upon some aspects of quality in flue-cured tobacco. A. B. PACK, N. C. State.

x*Absorption of radioactive phosphorus by mycorrhizal roots of pine.* P. J. KRAMER and K. M. WILBUR, Duke.

x*A report on the excavation of the site of an Indian village on the Yadkin River near Trading Ford.* C. D. HOWELL and D. C. DEARBORN, Catawba.

x*The bee fauna of the eastern United States.* T. B. MITCHELL, N. C. STATE.

x*The distribution of pest chiggers near Duke University.* G. W. WHARTON, Duke.

x*Life cycles of common pest chiggers* (Demonstration). G. W. WHARTON and C. E. FARRELL, Duke.

Investigation of ocean wreck problems; and destruction of immature food fishes. H. F. PRYTHERCH, U. S. Fish and Wildlife Service.

x*The effect of insecticides on the flavor of peaches.* C. F. SMITH, I. D. JONES, J. H. RIGNEY, N. C. State.

BIOCHEMISTRY AND PHYSIOLOGY SECTION

x*A study of the estimation of oxalic acid in foods.* E. T. VISER AND J. C. ANDREWS, U. N. C. School of Medicine.

x*Some further studies on magnesium-potassium antagonism in the animal organism.* SUSAN GOWER SMITH, Duke School of Medicine.

x*Sympatholytic effects of quinine and quinidine.* E. P. HIATT, U. N. C. School of Medicine.

x*Lipide phosphorylation in the liver as related to the dietary supply of methyl donors and methyl acceptors.* CAMILLO ARTOM and W. E. CORNATZER, Bowman Gray.

x*Lipide phosphorylation in the liver of rats fed thiourea and related compounds.* W. E. CORNATZER and CAMILLO ARTOM, Bowman Gray.

Induced tolerance to low barometric pressures. F. G. HALL, Duke School of Medicine.

Action of some inhibitors on the glucose-6 phosphatase of the liver. MARJORIE A. SWANSON, Bowman Gray.

x*Toxicity of radioactive phosphorus in mice on various diets.* W. E. CORNATZER, DAVID CAYER, G. T. HARRELL, JR., and CAMILLO ARTOM, Bowman Gray.

x*The effect of certain organic anions on peptide and amide linkages.* G. C. KYKER and S. L. STEELMAN, U. N. C. School of Medicine.

BOTANY SECTION

The accumulated sediments of Singletary Lake as indicating pleistocene and post-pleistocene change. D. G. FREY, U. N. C.

Amount of sore shin on medium and broad-leaf varieties of flue-cured tobacco. T. E. SMITH and S. J. HASSELL, McNair's Yield Tested Seed Co.

Tobacco leaf curl. F. A. WOLF, Duke.

A new group of organisms related to Actinomyces, J. N. COUCH, U. N. C.

The physiology of a blue stain mold with special reference to production of ethyl acetate. M. A. GORDON, Duke.

x*A fungistatic Actinomycete isolated from soil.* GLEN R. GALE and J. R. WARREN, Duke.

The compositae of Wake, Durham, and Orange counties. R. K. GODFREY, N. C. State.

x*Cytology, morphology, and taxonomy of* Diamorpha. J. E. O'CONNELL, Wake Forest.

A cytotaxonomic study of the North American Sarraceniaceae. C. R. BELL, U. N. C.

North Carolina plant distribution notes. W. B. FOX and R. K. GODFREY, N. C. State.

Preliminary cytotaxonomic study of Crotalaria. EARLENE ATCHISON, U. N. C.

The Sargassa of the West Atlantic. H. L. BLOMQUIST, Duke.

The peanut seedling: II. The morphology of hypocotyl and epicotyl. J. A. YARBROUGH, Meredith.

x*Causes of succession on abandoned fields in the Piedmont of North Carolina.* CATHERINE KEEVER, Duke.

GEOLOGY SECTION

A brief discussion of off-shore bars. S. L. BLANTON, U. N. C.

x*Outlier near Raleigh, North Carolina.* J. M. PARKER, III. N. C. State.

Stream piracy along the Blue Ridge. W. A. WHITE, U. N. C.

x*Talc and soapstone in North Carolina.* J. L. STUCKEY, N. C. State.

Some silica resources of North Carolina. S. D. BROADHURST, Department of Conservation and Development.

x*Ellipticity of Carolina Bays.* W. F. PROUTY, U. N. C.

x*Fossils from Harrellsville, North Carolina.* E. W. BERRY, Duke.

x*The breaking characteristics of argilutites.* R. L. INGRAM, U. N. C.

MATHEMATICS SECTION

x*On the approximation of irrational numbers by the convergents of their continued fractions.* ALFRED BRAUER and NATHANIEL MACON, U. N. C.

x*Multiple periodic functions.* J. M. THOMAS, Duke.

x*A remark on Oppenheim's paper: "Quadratic fields with and without Euclidean Algorithm."* O. H. HOKE, U. N. C.

x*On systems of linear equations.* J. W. LASLEY, JR., U. N. C.

PSYCHOLOGY SECTION

(N. C. Psychological Association)

x*Some relations of movement responses to creativity.* DOROTHY G. PARK, Meredith.

x*Methods of adjusting to success and failure in certain chronic medical disorders.* L. D. COHEN, Duke.

x*Music as a factor in industrial production.* WILLIAM MCGEHEE and J. E. GARDNER, Fieldcrest Mills.

x*Problems in the statistical combination of criterion variables.* DOROTHY C. ADKINS, U. N. C.

Presidential Address: Psychology in North Carolina—1949. WILLIAM McGEHEE, Fieldcrest Mills.

x*Consistency of production as related to personal and work data of some women textile workers.* H. C. OLSON, N. C. State.

x*Discrimination learning and performance in rats using continuous and intermittent reinforcement.* S. B. LYERLY, U. N. C.

The origin and extinction of emotionally negative avoidance behavior in rats. J. M. BEVAN, DUKE.

x*The use of galvanic skin response in testing pre-published advertising copy.* EDWIN GOLIN, U. N. C.

x*Survey of employee attitudes in a textile mill.* ORA M. JONES, Duke.

WILDLIFE SECTION

Food habits of the opossum in Sumter County, Alabama. R. J. WHEELER, JR. Wildlife Resources Commission.

Waterfowl kill and census data from Currituck Sound during the 1948–49 season. T. S. CRITCHER, Wildlife Resources Commission.

Some observations on the effects of airplane applications of DDT to forest and aquatic insects. H. K. TOWNES, N. C. State.

The technique of making fish models for educational purposes. H. F. PRYTHERCH, U. S. Fish and Wildlife Service.

Comparison of the microflora of a fertilized and unfertilized fishpond. L. A. WHITFORD, N. C. State.

x*Three piedmont reservoirs.* E. E. HUESKE, Wildlife Resources Commission.

The distributions of fishes in the Mississippi drainage system of North Carolina. J. R. BAILEY, Duke.

Age determination in gray squirrel populations. RAY ALLISON, N. C. STATE.

ZOOLOGY SECTION

Studies on the anatomy and course of ciliary currents in the stomach of Ostrea virginica. A. F. CHESTNUT, U. N. C. Institute of Fisheries Research.

x*Speciation in the field cricket,* Gryllulus assimilis *Fab.* B. B. FULTON, N. C. State.

x*Histological observations on the metamorphosis of male* Habrobracon. D. S. GROSCH, N. C. State.

x*The inheritance of ectrodactylism–a preliminary report.* C. D. HOWELL and T. S. BARRINGER, Catawba.

x*Parasitic crustaceans from Bimini.* A. S. PEARSE, Duke.

x*The circulatory system of conjoined twin calves.* W. O. PUCKETT, Davidson.

A midwinter "weather movement" of some small birds. T. L. QUAY, N. C. State.

x*Some comments on the study of Myrmecophiles.* M. W. WING, N. C. State.

x*A preliminary report on the use of chick embryonic extract in the culture of amphibian pigment cells.* H. E. LEHMAN, U. N. C.

Abstracts:

Origin of the Carolina Bays: Evidence from some Peat Profiles. B. W. WELLS.

Examination of the bottom peat in some shallow bays strategically located near the margin of the Talbot terrace in Brunswick County near Southport, N. C., disclosed the uniform presence of waterlily pollen, a certain indicator of open water conditions shortly after the time of bay formation. Had the depression been gradually formed in accordance with the solution theory, the basal peat would have been of the shrub-bog or related woody type, since the sites of these upland bays undergo seasonal fluctuation of the water table. During the dry periods any aquatic forms in the primary very shallow depressions would be eliminated. The woody shrub-bog species however, being adapted to both low and high water tables, would dominate the area.

While this evidence is definitely against the solution theory, it cannot be interpreted as direct positive evidence for any other theory.

Bioelectric Potential Transients Accompanying Closing Movements of the Lobes of Venus' Fly-Trap. OTTO STUHLMAN, JR., and E. B. DARDEN.

The method used for measuring the bioelectric potentials is a modified Wheatstone bridge arrangement designed by Burr, *et al.*, (Yale Jour. of Biol. **9**: 65–76, 1936) for measuring slow changes in mammalian potentials. Contact potentials of the electrodes across which the bioelectrical potentials were placed were minimized by using a pair of Ag-AgCl reversible electrodes in dilute KCl, terminating in a glass capillary containing a small asbestos-fiber wick, which served as the contact electrode on the surface of the plant where the e. m. f. originated.

Closure of the trap-like structure at the end of the spatulated petiole of Venus fly-trap normally follows when any one of the spike-like trigger hairs or the irritable inner epidermis is stimulated. The earlier work of the senior author showed that speed of closure depended on the pattern of excitation, which was hypothecated to originate as a localized destruction of the degree of polarization, which progressively spread as an equipotential electrical wavefront propagated over the surface of the lobe at about 3.0 cm. per sec. (Bull. Torrey Bot. Club **75**: 22–44, 1948).

The present experimental evidence shows that the hypothesis was justified. The excitatory wavefront was found to be a negative potential of about 0.05 volt for summer growth or as low as 0.01 volt for winter growth plants. It is measurable as a diphasic or monophasic potential pulse depending on the position of the nonpolarizable electrodes. The exact shape, speed, and origin of the electrical impulse is being explored with the aid of an oscillograph.

Absorption of Radioactive Phosphorus by Mycorrhizal Roots of Pine. P. J. KRAMER and K. M. WILBUR.

Since the absorption of mineral nutrients by mycorrhizal roots has not been measured directly, a study was made of the absorption of radioactive phosphorus (P^{32}) by mycorrhizal and non-mycorrhizal roots of pine. Root tips and root

segments were freed of foreign material and immersed in a dilute solution of P^{32} in the form of phosphate ion, having an activity of 100 to 500 microcuries per liter. After 3 or 4 hours the roots were removed, rinsed, and dried between glass plates and radioautographs made. Some roots were cut into segments and the amount of P^{32} present in each segment measured by Geiger-Müller counter.

Relatively little phosphorus was accumulated in the older suberized portions of the main roots and relatively high accumulations occurred in the unsuberized regions near the root tips. The coralloid clusters of mycorrhizal roots showed the largest accumulations, supporting the view that they are very active in the absorption of minerals. Relatively great accumulation also occurred even in those short roots which show none of the hypertrophy or dichotomous branching characteristics of typical mycorrhizae. Fungal hyphae appear to accumulate particularly large quantities of phosphorus. In a few instances autographs indicated that completely suberized roots had absorbed considerable phosphorus, but examination under the microscope showed that such roots were covered with a superficial layer of mycelium. Geiger counts of mycelium removed from roots also indicated high accumulation of P^{32}.

Addition of 0.001 M sodium azide, which inhibits respiration, to the solution reduced the accumulation of P^{32} in pine root tips to 42% of the control rate but only reduced accumulation in root segments bearing mycorrhizal branches to 67% of the controls.

It is clear that mycorrhizal roots can absorb much larger quantities of phosphorus than non-mycorrhizal roots. It seems possible that mycorrhizal roots not only have a greater surface, but also a greater capacity per unit of surface to accumulate phosphorus than non-mycorrhizal roots. Possibly phosphorus accumulation is inhibited to a greater extent by azide in non-mycorrhizal roots than it is in mycorrhizal roots.

A Report on the Excavation of the Site of an Indian Village on the Yadkin River Near Trading Ford. C. D. HOWELL and D. C. DEARBORN.

This site was originally on the southwestern bank of the Yadkin River about one mile below Dukesville. It is now covered by the waters of High Rock Lake most of the time, but when the water is low it emerges as an island. The northeastern border of the site has been washed away. Forty-seven hundred square feet of what remains have been excavated. This is but a small part of the total area of the whole village.

Forty-seven fire pits, shell pits, and refuse pits, in addition to uncounted small firebeds, have been discovered. Forty-six post molds have also been found and plotted on the map of the site. No recognized pattern has emerged from their arrangement thus far. One human burial of a mature female was uncovered. There were no cultural materials buried with it.

The Indian artifacts found lay consistently in a layer of blackened sand about eight inches thick and at an average maximum of about eight inches below the present surface. They include the following: 6,982 pot shards, representing possibly 200 pots; 446 arrowheads or points, mostly fragments; thousands of

chert chips; 24 chert drills; 9 bone awls; 18 hammerstones, most of them pitted; 49 rough-chipped chert "hoes"; 18 scrapers; 16 abrading and polishing stones; 3 pestles or fragments of pestles; 2 single-holed pendants; 2 parts of pottery pipes; 3 antler tools; many bones of mammals, birds, fish, and turtles; and parts of one human skeleton, including a fairly complete skull and right femur.

No articles of European origin have been found. Therefore, the village is tentatively considered to antedate the period of contact with European traders and to be older than Saponi Village mentioned by Lawson as being at Trading Ford in 1701.

The Bee Fauna of the Eastern United States. T. B. MITCHELL.

A synopsis of the bees of the eastern United States is in course of preparation. Approximately 750 species, in each sex, have been keyed out, about 180 of these apparently being new to science. This large number of undescribed forms is indicative of the incomplete state of our knowledge of these insects. Revisional work is needed badly in several of the groups, and a more complete knowledge of their habits and ecological relationships with the flowering plants, including the crop plants.

Bees exhibit a wide range of variation in size, structure, color and habits. Most of them are solitary, nesting in the soil or in a variety of sites above the ground surface. Flight periods tend to be long in the more generalized species, which visit a considerable range of flowers, but are short in the more specialized oligolectic forms which visit only one or a very limited number of plants. The period of greatest activity is from mid-morning to mid-afternoon. Bees are among the most essential of the beneficial types of insects, because of their importance in the pollination of the numerous important plants. The honey bee is the most valuable single species, but the role of the wild bees in general is an important one, and studies are needed to determine which are of more importance and to discover means for their conservation.

The Distribution of Pest Chiggers Near Duke University. G. W. WHARTON.

The distribution of pest chiggers near Duke University has been studied from several aspects during the last year and a half with the support of a grant-in-aid from the Division of Research Grants and Fellowships of the National Institute of Health, U. S. Public Health Service. Daily collections have been made and correlations with temperature and rainfall have been attempted. The last chigger of the 1947 series was collected on October 20. The first specimen of 1948 was collected on May 17. During 1947 the greatest number of specimens was collected during the last week in July and the first week in August. Larvae were uncommon when subsurface temperatures dropped below 60°F. Not enough data have been accumulated in this study to detect the seasonal effects of rainfall on the numbers of chiggers collected. The diurnal distribution of chiggers was investigated by making hourly observations continuously for 62 hours. Chiggers were collected most abundantly during daylight hours but the temperature records indicate that the chiggers were most readily collected between temperatures ranging from 75 to 85°F, and that time of day is not of itself the controlling

factor. During part of the time of the hourly observations rain fell. When the ground was covered with droplets of water few chiggers were collected. The distribution of chiggers in respect to soil and type of cover was also investigated. Chiggers were collected more frequently in loam than in either clay or sand. They were most common in brambles and practically non-existent under hardwood stands.

Life Cycles of Common Pest Chiggers. G. W. WHARTON and C. E. FARRELL.

In the course of work on a U. S. Public Health Research Grant, colonies of pest chiggers have been maintained for the past two years. There are eight stages in the life cycle as follows: egg, deutovum, larva, nymphochrysalis, nymph, imagochrysalis, males and females. Preserved and living specimens of these stages were shown.

The Effect of Insecticides on the Flavor of Peaches. C. F. SMITH, I. D. JONES, and J. A. RIGNEY.

Peach trees were sprayed with benzene hexachloride (10 per cent gamma isomer), chlordane, chlorinated camphene, parathion, or lead arsenate at different times during the growing season. Samples from the various plots were picked when the peaches were ripe, analyzed for spray residue and taste-tested for off-flavor. In the flavor tests the peaches receiving only lead arsenate were used as a standard. Flavor tests were conducted on fresh and canned fruit.

Analyses of residue on the fruit at harvest were made for benzene hexachloride, parathion, and chlorinated camphene.

In the flavor tests, benzene hexachloride affected the flavor of fresh fruit. The flavor of the canned fruit was similarly affected by the benzene hexachloride except where it was used only in the petal fall and shuck-off sprays. The off-flavor became more noticeable as the number of sprays were increased or as they were applied nearer harvest.

Parathion and chlordane gave somewhat erratic performance in the flavor tests. Twice parathion was significantly better than anything else in the test, while in one test it was poorer than lead. Chlordane was by far the best in two tests. In another test it was even significantly worse than 4 applications of benzene hexachloride. However, when results of all the tests were pooled there was no significant difference between lead arsenate, chlordane, or parathion.

Studies on the Determination of the Oxalic Acid Content of Some Common Foods. E. T. VISER and J. C. ANDREWS.

Since there seemed to be a higher incidence of kidney and bladder stone formation in eastern North Carolina than would be considered normal, it has been suspected that this section may be included in a "stone district", a geographical area which for one reason or another exhibits this higher than normal incidence of stone disturbances among its populace. In an effort to find out if the common foods grown in the area might be responsible, a study was begun of the oxalic acid content of 43 foods. Briefly, the method included the following

procedures: the food was thoroughly dried and defatted with CCl_4 (if the fat content was above 2–4%). The dried material was ground until it would pass through a 16-mesh screen. A representative portion was taken and kept in a desiccator until samples were needed for analysis. Two- to four-gram samples of the food material were placed in sintered glass extraction thimbles and extracted with HCl in Soxhlet extractors. The resulting acid extracts were filtered, made to volume, and aliquots extracted with ether in modified Clausen extractors. Water was added to the resulting ether extracts, the ether distilled off and the oxalic acid remaining in the aqueous solutions precipitated with saturated $CaCl_2$ solution. After the precipitates were centrifuged and the supernatant portions discarded, the CaC_2O_4 was dissolved in normal H_2SO_4, heated and titrated with standard $KMnO_4$. Using samples of foods to which known amounts of oxalic acid were added we have established the optimal conditions for this determination with respect to the various steps in the method.

Some Further Studies on Magnesium-Potassium Antagonism in the Animal Organism. SUSAN GOWER SMITH.

A paralysis produced in the laboratory on a diet low in potassium and lacking several B complex factors has some characteristics in common with the paralysis produced by intravenous injection of magnesium. Both are flaccid, affecting the extremities and both have a definite inhibitory effect on respiration. The respiratory rate decreases to a marked degree. Death, when it occurs, is due to respiratory failure in both instances. Though etiologically different they appear to operate through a common neuro-mechanism.

It has been reported (Arch. Biochem. **20**: 473, 1949) that the i. v. administration of $MgSO_4$ results in a consistent decrease in the serum potassium level. Preliminary experiments in which four dogs were given potassium chloride at different concentrations coincidently with the magnesium sulfate would seem to indicate that the respiratory symptoms correlate rather closely with the serum potassium level. Where the potassium chloride injected was sufficient to maintain normal or higher than normal serum potassium values, the respiratory inhibition was wiped out. The respiratory rate was actually increased when the serum potassium was forced to a level higher than normal.

Sympatholytic Effects of Quinine and Quinidine. E. P. HIATT.

The antagonistic effect of oral and intravenous doses of quinine and quinidine on the circulatory action of intravenously injected epinephrine has been studied in anesthetized and unanesthetized dogs. It was found that plasma concentrations of 5 to 10 mgm. per liter of these alkaloids will block the pressor effect and changes in rate which follow injection of test doses of epinephrine (0.5 cc. of 1:10,000).

It was further demonstrated that similar concentrations will block the pressor effect of stimulation of the splanchnic nerves of anesthetized dogs.

These findings correlate with our previous demonstration that the cinchona alkaloids will cause renal vasodilation and lower the blood pressure of dogs with experimental neurogenic hypertension. Evidence exists to indicate that these agents can block all types of motor nerve endings.

Lipide Phosphorylation in the Liver as Related to the Dietary Supply of Methyl Donors and Methyl Acceptors. CAMILLO ARTOM and W. E. CORNATZER.

The hypothesis that the dietary supply of transferable methyl groups represents a limiting factor for the synthesis of phospholipides in the liver would offer a rather simple explanation of the lipotrophic action of choline or choline precursors. The findings of an increased turnover of liver phospholipides (especially of the lecithins) following the administration of choline is in line with this hypothesis. Since, however, similar effects have been observed after ethanolamine was given, it has been postulated also that a relative deficiency of both methyl donors and methyl acceptors for the synthesis of choline might occur in animals on very low protein diets.

This possibility has now been investigated by comparing the isotopic concentrations in the liver lipides of rats maintained on various diets and killed six hours after administration of Na_2HPO_4 containing radioactive P.

The average specific activity of the lipide P in rats on a stock diet was lower than in rats on a 5 per cent casein, high fat diet, which caused an extensive fatty infiltration of the liver. When this diet was supplemented with ethanolamine, or with methionine, or with both, somewhat higher values were usually found. Much more marked increases in these values were observed following the isolated or combined administration of a single large dose of these substances. These increases were approximately of the same magnitude in the groups on the unsupplemented diets as well as in those on diets supplemented with the methyl donor, or the methyl acceptor only, or the mixture of the two. Considerable decreases in the specific activity of the total phospholipides (more especially of the choline-containing portion) were observed only in experiments in which the diets were supplemented with quanidoacetic acid or with diethanolamine.

From the present results as well as from other data of the literature, no simple correlation is apparent between the rate of lipide phosphorylation in the liver and the amounts of lipotropic factors in the diet. Even with diets which contain little protein and no preformed choline, choline and ethanolamine seem to be available to the animal in amounts adequate for the synthesis of phospholipides in the liver at a rate much above the "normal" level. A deficiency of the nitrogenous precursors for the formation of phospholipides in the liver becomes apparent only after the addition to the diets of substances which either compete for the methyl groups (e. g. quanidoacetic acid) or act presumably as metabolic antagonists of the methyl acceptor in the synthesis of choline (e. g. diethanolamine).

(This work was supported by the U. S. Atomic Energy Commission under Contract No. N8onr-63701 between the Bowman Gray School of Medicine and the Office of Naval Research, U. S. Navy Department. The P^{32} used was supplied by the National Laboratory, Oak Ridge, Tennessee, on allocation from the U. S. Atomic Energy Commission).

Lipide Phosphorylation in the Liver of Rats Fed Thiourea and Related Compounds. W. E. CORNATZER and CAMILLO ARTOM.

Several groups of male albino rats of about 80 g. body weight were given various antithyroid drugs (thiourea, thiouracil and N-propylthiouracil) for periods varying between 15 and 35 days. The rats were maintained on diets with an adequate protein content, but during the last week of the experiment, they were transferred to a low protein, low fat diet (Diet 26 containing casein 5 parts, Crisco 4, cod liver oil 1, dextrin 42, sucrose 42, roughage, salts and B-vitamins). As a rule, the drugs were added to the diets, but in many of the experiments additional amounts were given parenterally or by stomach tube. Control groups were run simultaneously and fed the same diets, but did not receive the substances tested. At the end of the experiments all animals were injected intraperitoneally with a solution of Na_2HPO_4 containing P^{32}, and, after six hours, they were killed by decapitation. The lipides extracted from the liver were weighed and their radioactivity and phosphorus content determined. In the first series of experiments, the radioactivity of the lipides extracted from some of the rats receiving the drugs were extremely low. However, efforts to reproduce these occasional findings with greater frequency and consistency were not successful. Even if these exceptionally low results are disregarded, the average specific activity of the lipide P in the liver of the rats receiving the substances was significantly lower than in the controls.

In a second series of experiments, the isotope and phosphorus determinations were made not only in the lipide extracts, but also in the inorganic fraction. Thus, it became possible to express the specific activity of the lipide P as a function of the specific activity of the inorganic P ("relative specific activity"). When the relative specificity values were compared, the difference between the averages in the treated and untreated rats became even more marked and more significant. A decrease of the same order of magnitude was noted also in the specific activity of the lipides from a few rats which received thioacetamide, a compound which recently has been claimed to cause cirrhotic lesions in rat liver.

In a third series of experiments the food intake of the control rats was restricted to approximately the same amounts as that of rats receiving thiourea. The average specific activities of the lipide P in the liver of both treated and untreated animals were approximately the same. When, however, the values were expressed as "relative specific activity," a significant decrease in the animals receiving the drug is again apparent. On the contrary, in seven rats in which a total thyroidectomy was performed, there was no significant change from the controls either in the specific activity or in the relative specific activity of the lipide P. It seems likely that the decreased formation of phospholipides in the liver of animals receiving thiourea and related substances is chiefly due to a direct pharmacological action of the drugs administered.

(This work was supported by the U. S. Atomic Energy Commission under Contract No. N8onr-63701 between the Bowman Gray School of Medicine and the Office of Naval Research, U. S. Navy Department. The P^{32} used was supplied by the National Laboratory, Oak Ridge, Tennessee, on allocation from the U. S. Atomic Energy Commission).

Toxicity of Radioactive Phosphorus in Mice on Various Diets. W. E. CORNATZER, DAVID CAYER, G. T. HARRELL, JR., and CAMILLO ARTOM.

The present investigation is a part of a more extended study undertaken with the idea that the resistance of the organism to the toxic effects of radioactive isotopes introduced into the body may be decreased by alterations in the functional capacity of the liver. This point would, of course, be of practical interest for the use of radioactive isotopes as diagnostic and therapeutic agents in patients with liver diseases since in these individuals even small doses of radioactivity could exert an additive harmful action.

To our knowledge, the only data on the toxicity of P^{32} are those of Anthony and Snyder (Atomic Energy Commission, Document MDDC-881). On the basis of a few experiments on mice (presumably maintained on a stock diet), these authors suggest that the LD_{50} after one injection of P^{32} is around 4 microcuries per gram of body weight. With this dose 4 out of 6 mice died between 16 to 21 days.

In the present experiments we have studied the mortality and survival time of mice maintained on diets of known composition and injected with radioactive phosphorus as sodium diphosphate. We have investigated the possible role of a deficiency of lipotropic factors in the diet, such a deficiency leading to a fatty infiltration of the liver. If in this condition the toxicity of the isotope were increased, supplementation of the diet with choline should give a more or less marked protection.

Several groups of mice (approximately 20 gm. body weight) were transferred from a stock diet to a low protein, high fat diet (Diet 31, containing casein 10 parts, Crisco 30, cod liver oil 2, sucrose 29, dextrin 23, roughage, salts and B vitamins). The animals were maintained for five days on the diets, then they were injected with a single dose of radioactive phosphorus and kept under observation for three weeks. To date, a total of 120 mice have been used.

There were no deaths among mice not injected with radioactive P and maintained for 25 days on the unsupplemented diet. Of the animals injected with 2 microcuries per gram of body weight and maintained on either the unsupplemented or supplemented diet none died in 21 days. With 4 microcuries per gram of body weight the mortality at the twenty-first day was 16% and the average survival time was of 20 days for both the controls on the unsupplemented diet and the mice of the choline supplemented diet. With 6 microcuries per gram of body weight the mortality has been 72% and 86% and the survival time 16 and 12 days respectively. With 8 microcuries per gram of body weight the mortality was 89% and 89% and the average survival time 12 and 13 days respectively.

In another group of rats injected with 6 microcuries per gram of body weight the level of the fat in the diet was decreased from 32 to 5 per cent (Diet 34). There was a slight decrease in mortality but no change in the survival time after injecting 6 microcuries per gram. Likewise, no significant protection was observed when the protein content of the low fat, low protein diet was increased from 10 to 26% (Diet 29).

(This work was supported by the U. S. Atomic Energy Commission under a

contract with the Bowman Gray School of Medicine. The P^{32} used was supplied by the National Laboratory, Oak Ridge, Tennessee, on allocation from the U. S. Atomic Energy Commission).

The Effect of Certain Organic Anions on Amide and Peptide Linkages. G. C. KYKER and SANFORD L. STEELMAN.

The rates of hydrolysis at 65°C. of the amide and peptide linkages of certain proteins (egg albumin, serum albumin, gelatin and hemoglobin) by hydrochloric acid in the presence of certain organic anions depend on the concentration of the protein, the anion, and the hydrochloric acid and on the nature of the protein. Most important of all is the ratio of the concentration of the protein to the concentration of the anions. The differences in the hydrolytic effectiveness of the organic anions do not parallel, in all cases, the differences in the affinities of the anions of the acids for proteins as suggested by Steinhardt (J. Research NBS **29**: 315, 1942). A maximum rate of amide hydrolysis is reached with sodium dodecyl sulfonate and egg albumin. This is not the case with the other proteins studied. Sulfosalicylic acid, which has an "intermediate" anion affinity for wool protein, inhibits amide hydrolysis of egg albumin.

The catalytic effect of organic anions on the peptide hydrolysis is limited to the initial stages of hydrolysis and when the protein is further split, the rate tends to approach that of HCl. For the ones studied, when the protein was approximately 25% hydrolyzed the rate began to approach closely that of the HCl.

The mechanism for the catalytic effect is uncertain but may be due to the denaturating action of the anion on the protein and to the combination with it. As the hydrolysis proceeds, there is evidently less tendency of the anion to combine and the rate of hydrolysis approaches that of HCl.

The Physiology of a Blue Stain Mold with Special Reference to Production of Ethyl Acetate. MORRIS A. GORDON.

An ascomycete, *Endoconidiophora moniliformis* (Hedge.) Davidson, which causes blue stain of pine wood, produces, when grown in pure culture, an odor similar to that of banana oil. This odor is found to result from the presence of ethyl acetate, which is formed when the fungus is cultured on any of several chemically known media. Thiamin must be supplied for the growth of *E. moniliformis* on these media, in which the production of esters parallels gain in dry weight of the fungus. Among the initial materials (carbon sources) from which ethyl acetate is derived are dextrose and ethyl alcohol. Asparagin, urea, and several other organic nitrogen compounds serve as good nitrogen sources for both growth and ester production. A discussion of the possible phase-sequence involved in the production of ethyl acetate is presented.

A Fungistatic Actinomycete Isolated from Soil. G. R. GALE and J. R. WARREN.

In a study of the effects of DDT on the microflora of soils, tomato plants were sprayed with a solution of 200 parts per million DDT. From the soil in which

these plants grew a fungistatic actinomycete has been consistently isolated. In Petri dish cultures this organism has strongly inhibited a wide variety of fungi. That the inhibitory substance is an extracellular diffusible compound is indicated by the occurrence of fungistasis at distances of approximately two centimeters from the actinomycete colony.

Among the inhibited organisms are the following: *Mucor genevensis* Lendner, *Rhizoctonia solani* Kuhn, *Sclerotinia cinerea* (Bon.) Wor., *Sclerotium rolfsii* Sacc., *Alternaria tenuis* Nees, *Helminthosporium sativum* Pam., *Venturia inaequalis* (Oke.) Aderh., *Epidermophyton interdigitale* (Priestley) MacCarthy, *Blastomyces dermatitidis* Cast., *Trichophyton mentagrophytes* Gedoelst.

Cytology, Morphology, and Taxonomy of Diamorpha cymosa. J. E. O'CONNELL.

Two species of *Diamorpha* have been reported from North Carolina; however, this paper recognizes only one of them as a good species. This conclusion is based on the general characteristics of the plants in conjunction with previous observations.

Diamorpha cymosa appears sporadically in Georgia, Tennessee, South Carolina, and North Carolina. It is an herb which belongs to the order Rosales and to the family Crassulaceae.

Each of the four ovaries, which make up the compound ovary, begins its development independently from a single cell in the base of the flower. After many mitotic divisions, the ovaries become fused for about one-half of their length.

The growth of each stamen begins from a superficial cell in the base of the flower. This cell actively divides to produce a mass of sporogenous tissue which is pushed up from the base of the flower by the stalk of the anther.

The microsporangia develop in the usual manner. Spore mother cells pass through meiotic divisions to produce the tetrad. The spores are released and develop to maturity.

The ovule shows a nucellus and two integuments. The integuments are two cells in thickness. The megaspore mother cell is produced from a subepidermal cell. It produces four megaspores, only one of which develops to form the embryo sac. The mature embryo sac is very small (25 microns and less) and it must be observed under oil. It contains one large egg, two oval-shaped synergids, three small antipodals, and two small polar nuclei.

Diamorpha cymosa has a chromosome number of $2n = 18$.

Causes of Succession on Abandoned Fields in the Piedmont of North Carolina. CATHERINE KEEVER.

Causes of succession were sought in the life cycles of, and effects of environmental factors on, the three major dominants: horseweed (*Leptilon canadense* L.), aster (*Aster ericoides* (L.) Britton), and broomsedge (*Andropogon virginicus* L.), which were studied in the field and greenhouse. Horseweed is the dominant of first year fields because the seeds mature and are ready to germinate at the time most farm land is being cultivated the last time for the season. Horseweed

loses its dominance the second year because the seedlings are stunted by decaying horseweed roots, and because of the competition among the numerous horseweed plants and young asters. Aster is delayed in assuming dominance until the second year because it germinates about six months later than horseweed and is retarded in growth by the shade and competition of the established horseweed, and by the effects of decaying horseweed roots. Aster loses its dominance at the end of the second year because the first generation fails in competition with the more drought-resistant broomsedge that is becoming established at that time, and because the seedlings are not able to grow to maturity in the shade of the increased vegetation. Broomsedge is delayed in assuming dominance until the third year because there is not a sufficient source of seeds until that time. A species may become dominant, not because a previous invader makes the environment more favorable for it, but in spite of the effects of the original invader.

Outlier near Raleigh, North Carolina. J. M. PARKER, III.

An outlier of Coastal Plain sediments occurs on the Johnston-Wake county line near U. S. Highway 70 about ten miles southeast of Raleigh, N. C. It rests on granite and is overlain by "high-level" (? Pleistocene) gravel and sand. The lower portion consists of consolidated ferruginous sandstone; higher beds are a completely silicified coquina containing fragmentary molluscs, coral, and palm wood. Eocene age is suggested.

Talc and Soapstone in North Carolina. J. L. STUCKEY.

Talc and soapstone deposits are widely scattered throughout the Appalachian mountains and Piedmont plateau of North Carolina and occur in three geological settings. These settings are: (1) in peridotites, dunites, and pyroxenites; (2) in hornblende gneisses and schists; and (3) in dolomitic limestones and marbles. In the deposits associated with (1) and (2) soapstone predominates, while in those associated with (3) talc predominates. All the deposits are genetically similar in that they have been formed by hydrothermal solutions of igneous origin.

Ellipticity of Carolina Bays. W. F. PROUTY.

The ellipticity of 130 bays from four counties in North and South Carolina was measured. These bays varied in length from 500′ to 6000′. The maximum ellipticity was 0.457; the minimum was 0.270 and the average was 0.363.

There is a variation in the ellipticity of bays of all sizes but a larger variation in the bays of smaller size. In every locality where measurements were made the larger bays have an average ellipticity greater than that of the smaller bays. The meteoritic theory of bay origin offers an explanation for the above observed facts.

In passing through the atmosphere the heat of friction causes some meteorities to break open or suffer mild explosion. Due to this the fragments travel slightly different paths which give different orientations to the bays formed by the different pieces which were thrown to the right or the left. The pieces thrown more

upward would form bays with greater ellipticity, and those thrown more downward would form bays with less ellipticity. As a rule, the smaller fragments would be thrown into a travel course more at variance with that of the parent meteorite than would larger fragments. Unless the bursting of the parent meteorite occurred close to the Earth the greater slowing down of the smaller meteorites than of the larger would, in many instances, allow the larger fragments travelling less curved paths to form bays with even greater ellipticity than that of the smaller meteorites which were thrown more upward and forward by the mild atmospheric explosion of the parent meteorite.

Fossils from Harrellsville, North Carolina. E. W. BERRY.

Vermetus graniferus Say, *Turritella plebeia* Say, *T. cf. variabilis* Conrad, *Cepidula fornicata* (L.), *Corbula inaequalis* Say, *C. cuneata* Say, *Spisula subponderosa* (d'Orb.), *Ensis directus* (Conrad), *Venus mercenaria* L., *Venericardia granulata* Say, *Astarte calvertensis* Olen, *Plicatula densata* Conrad, *Pecten jeffersonius* var. *septenarius* Say, *Ostrea percrassa* Conrad, *Glycymeris subovata* (Say), *Arca subrostrata* Conrad, *Leda liciata* (Conrad), *Nucula prunicola* Dall, and *Septastrea marylandica* (Conrad) have been tentatively identified from an outcrop on the east side of the road going from Harrellsville to Wiccoon River just before you reach the ferry. These can all be referred to the upper Miocene or Yorktown Epoch. There is about 10 feet of Yorktown at the locality with about 5 feet of Pliocene-Pleistocene sands on top.

The Breaking Characteristics of Argilutites. R. L. INGRAM.

Clay sediments break into fragments that can be described as massive, flaky, flaggy, or some combination of these. The parameters that control the breaking characteristics are numerous and not completely known.

Analyses show that grain size, carbonate content, and kinds and proportions of clay minerals cannot explain the differences in breaking characteristics in a random collection of argilutites. The massive varieties are characterized by a random arrangement of the clay particles, a very low organic content, and the presence of primary colloidal sesquioxide or silica particles which interfere with the parallel orientation of the clay particles. The non-massive varieties are characterized by a sub-parallel or parallel arrangement of the clay particles, a higher organic content, and the absence of primary colloidal sesquioxide particles. Flaky and flaggy forms differ only in that the flaggy ones contain more tempering cement.

On the Approximation of Irrational Numbers by the Convergents of Their Continued Fractions. ALFRED BRAUER and NATHANIEL MACON.

Let ζ be any positive irrational number, and let A_n and B_n denote the numerators and denominators of the convergents in the expansion of ζ as a regular continued fraction. We set

$$\left|\zeta - \frac{A_n}{B_n}\right| = \frac{1}{\lambda_n B_n^2}$$

In 1891 Hurwitz obtained the important theorem that there exist infinitely many λ_n which are greater than $\sqrt{5}$ for every ζ. It was proved by Vahlen in 1895 that of each pair of consecutive λ_n at least one exceeds 2, and by Borel in 1903 that at least one of three consecutive λ_n is greater than $\sqrt{5}$.

It is shown in this paper that of each five consecutive λ_n, either at least two exceed $\sqrt{5}$, or at least one of them exceeds 3. Similar results are obtained for any set of $3\ m + 2$ consecutive λ_n $(m = 2, 3, \ldots)$. Moreover,estimates for sums and products of consecutive λ_n are obtained. In particular, it is shown that

$$\liminf \frac{1}{m}\left(\sum_{i=0}^{m-1} \lambda_i\right) > 2.0169$$

Multiple Periodic Functions. J. M. THOMAS.

It is known that a non-constant analytic function can have one or two but not three independent periods and that the ratio of two independent periods is necessarily imaginary. The present paper bases a proof of these results on geometrical considerations.

A Remark on Oppenheim's Paper: "Quadratic Fields with and without Euclidean Algorithm." O. H. HOKE.

A. Oppenheim (Mathematische Annalen **109**: 349–352, 1934) proved that the real quadratic fields $P(m)$, were $m = 2, 3, 5, 6, 7, 13, 17, 21, 29$, are Euclidean fields. Some other real quadratic Euclidean fields are known, but the problem of finding all such fields is not solved completely.

Oppenheim's proof is also given in Hardy and Wright's *An Introduction to the Theory of Numbers*, second edition (1945), pp. 213–215.

In this paper it will be shown that Oppenheim's proof can be simplified somewhat.

On Systems of Linear Equations. J. W. LASLEY, JR.

It is customary in developing the theory of linear equations first to establish Cramer's Rule and then the theorems of non-homogeneous linear equations. The theory of homogeneous linear equations is regarded, from this approach, as a special case in which the constant terms are all zeros.

The present paper approaches the problem in the reverse manner by developing the theory of homogeneous linear equations first, and obtaining the theory of non-homogeneous linear equations as a special case.

The product structure of the homogeneous linear function together with three fundamental theorems of determinants provide the basis of the development. The existence of a non-trivial solution of the system of homogeneous linear equations is proved at the outset for the case in which the number of unknowns in the system differs from its rank by unity. The proofs of the uniqueness of this solution (except for a proportionality factor) then follows. An alternative form of this solution is obtained and identified with the solution shown earlier. Cramer's Rule next is pointed out as a special case.

For the case in which the rank of the system has any admissible value, a canoni-

cal form for the system is secured involving a replacement principle of columns of certain matrices. The coefficients in this canonical form have properties similar to Kronecker deltas. Questions of existence, uniqueness, and the form of the general solution are considered. A generalization of Cramer's Rule is obtained.

Some Relations of Movement Responses to Creativity. DOROTHY G. PARK.

Problem: To investigate the relation of responses on the Levy Movement Blot test to creativity in college students and thus check on Rorschach's claim that creativity is a correlate of the movement response.

Population: Forty female juniors and seniors in college, twenty judged by students and teachers to be creative, twenty judged as average or non-creative; a second group of 50 college students, including the above plus ten more, five of which were creatives of superior intelligence for whom appropriate non-creative matches could not be found.

Procedure: After the two groups were equated for age, education, sex, and intelligence level, the Levy Movement Blots were administered to each subject individually and the resulting data compared, on the basis of psychometric scoring of movement responses, also of phantasies about each response.

Results: Scores of the 40 protocols of the first group of creatives and non-creatives on the Levy Movement Scale and on the Zubin-Rust Compliance Scale yielded slightly negative relationships between movement responses and creativity. This confirms the finding of Rust in his experiments with the Levy test. However, this agreement with Rust's data does not extend to all the movement scales, as the creatives show up better on the Energy of Movement, Interaction, and Conflict scales, the difference on the Conflict scale being 25%. The highly significant difference of 136% in favor of the creatives appears in the Abstract-Concrete Scale. The Sex Reference Scale shows 69½% difference in favor of the non-creatives. The Park Phantasy Scales show higher scores on Organization made by the non-creatives, but higher scores on Originality and Sensitivity by the creatives.

Scores of the second group, with the over-weight of intelligence in the creatives, yielded similar results in the first three scales. Differences on other scales, particularly a difference of 263.63% higher score for the creatives on the Abstract-Concrete Scale and differences of 10–15% on each of the Phantasy Scales point to the conclusion that intelligence is an important factor in the relationship between movement responses and creativity.

The author disagrees with Rust's interpretation of negative relationships found on the Zubin-Rust scales as proving that "the production of movement responses on the Levy Movement Blots does not have the same relationship to creativity as is claimed for the M response by Rorschach."

Methods of Adjusting to Success and Failure in Certain Chronic Medical Disorders. L. D. COHEN.

Problem: Are there characteristic and different methods of adjusting to success and failure among groups of patients suffering from different chronic medical disorders?

Population: A group of 26 subjects diagnosed with hypertensive cardiovascular disease, a group of 21 subjects with asthma, a group of 25 college students with no history of chronic medical disorders or psychoneuroses or psychoses.

Procedure: All subjects participated in a level of aspiration task involving the Rotter aspiration board. Methods of reacting to success and failure were noted by a number of measures derived from the differences between aspiration bid and actual performance. These measures included: (1) number of shifts (number of changes in aspiration bid), (2) number of shifts appropriate to the previous performance (raising bid after success, lowering bid after failure), (3) number of shifts opposite to the previous performance (lowering bid after success, raising bid after failure), (4) number of failures to shift after success and failure, (5) number of failures to state new bid until reminded by examiner. On the basis of these measures four major methods of adjustment to success and failure were denoted and a rating scale developed: (1) rigid, (2) arbitrary, (3) flexible, (4) conforming. The reliability of the ratings on methods of adjusting to success and failure gave a corrected contingency coefficient of .920 significant at the 1% level of confidence. A validation study utilizing a group of 50 patients from the subjects listed above on whom Rorschach studies had been conducted yielded a corrected contingency coefficient of .658 significant at the 1% level of confidence between ratings based on the level of aspiration and the Rorschach performance.

Results: The hypertensive group used the arbitrary and conforming types of adjustment in preference to any other while the asthmatic group predominantly used the rigid type of adjustment. The types of adjustment were not exclusive for either group but the trends seemed strongly suggestive for each group. The control group showed a preference for the flexible and conforming types of adjustment.

Conclusions: From an analysis of the behavior following success and failure in a level of aspiration task, certain characteristic methods of adjustment become apparent. These methods of adjustment when denoted seem consistent for the subject as determined through the use of another task having entirely different properties (Rorschach). The types of adjustment to success and failure utilized by groups of patients suffering from different chronic medical disorders is suggestively characteristic for each disease and different for different chronic medical disorders.

Music as a Factor in Industrial Production. WILLIAM MCGEHEE AND J. E. GARDNER.

An investigation was made of the effect of music upon 142 female industrial employees performing a highly complex job known as rug setting. The investigation determined the effects of music on production, absenteeism, and employee attitudes.

Music was found to have no significant effect on production. This conclusion was based on (1) a comparison of production on music days with production on no-music days during an experimental five-week period, and (2) a comparison of production during a five-week period prior to the installation of music with production during a five-week period subsequent to the experimental period.

Music appeared to have a salutary effect on absenteeism. A significant drop in absenteeism occurred in the department with the introduction of music. No significant change occurred in another department of equivalent size or in the mill as a whole.

A survey of employee attitudes, conducted by means of interviews and a questionnaire, indicates that music reduced fatigue and increased job satisfaction. A similar survey conducted among supervisors revealed that the supervisors thought the music had improved interpersonal relations, had made their own job tasks easier to perform, and had increased their job satisfaction.

Problems in the Statistical Combination of Criterion Variables. DOROTHY C. ADKINS.

When the relations between each of a set of variables with a single criterion are known, the weights at which the predictor variables should be combined to predict best the criterion can be determined by the multiple correlation approach. Not infrequently in psychological research, however, the ultimate variable in which interest centers is not capable of being measured directly, but several proximate criteria are available. When the relations between each of a set of predictor variables and each of these proximate criteria are known, the problem arises of how best to weight not only the predictor variables but also the criterion variables.

It is noted that, when the number of criterion variables is large, how they are weighted is of little significance. Two situations are distinguished for a small number of criterion variables: (1) that in which all of the criterion variables are assumed to be measures of the same factor; (2) that in which the various criteria are more reasonably to be regarded as different components or relatively independent aspects of an over-all activity in which it is desired to appraise success. In either case, there is the problem of how to combine into a single index the several criterion measures, each weighted on the basis of its respective importance. Characteristics of several solutions that have been proposed are briefly described, but the point of view is taken that no one of them obviates the need for value judgments within the subject-matter area of the investigation in question. Application of factorial analysis to the criterion variables, perhaps together with the predictor variables, may provide a promising approach.

Consistency of Production as Related to Personal and Work Data of Some Women Textile Workers. H. C. OLSON.

Problem: To measure the relationship of consistency of production of spinning-frame operators to the personal variables of age, education, marital status, and number of dependents, and the work variables of seniority, experience, place of residence, merit rating, absences, average hourly production, and total production.

Subjects: The sample is made up of 56 women ring-spinning-frame operators employed in a cotton sheeting mill. It included all spinners within the department who met the imposed criteria of having had a minimum of one year's ex-

perience immediately preceding the experimental period, and of having been absent from work less than one half of the experimental period.

Method: Data for the study were obtained from personnel record forms and from payroll accounts of the spinners. Records of standard time production were collected for the eight-week period from September 8 to November 2, 1947, and, by computing the average deviation, a value of variability in production was derived for these eight periods. This measure of variability (called the Consistency Index) was compared with the variables listed previously by employing chi-square and product-moment correlation techniques. Data pertaining to absence were portrayed graphically by dividing the sample into three equal units on the basis of the Consistency Index.

Results: Consistency Index values show a wide distribution and, when plotted, result in a positively skew curve. Chi-square values and coefficients of correlation revealed no direct relationships that were significant at the 5% level of probability. Some trends are suggested, however, by relatively high chi-square values between the Consistency Index and the variables of experience, per cent of voluntary absences, and per cent of asked-off absences. The highest correlations obtained were those for experience (−.21), voluntary absences (.16), and asked-off absences (−.20). In general, spinners who were the most consistent in their week-to-week production tended to have greater seniority, more experience, less education, a lower percentage of voluntary absences, a higher percentage of asked-off absences, fewer periods of sickness, and more hours on the spinning job during the period studied.

Conclusion: Chi-square and correlation methods disclosed no relationships that were significant at the 5% level. The per cent of categories of absences (voluntary, asked-off, or sick) suggest the best trends. These results are interpreted as showing the more consistent spinners as having either a greater sense of responsibility toward their employer or more pleasant working relationships with their foremen, and these being reflected in the spinners' absence records. The trend with respect to experience is interpreted as a stabilization of work habits and a fitting of work speed to the pace of the spinning machinery.

Discrimination Learning and Performance in Rats Using Continuous and Intermittent Reinforcement. S. B. LYERLY.

Hungry white rats were trained to go to the lighted side in a T-maze. Food reward for a correct response was given on every trial when the light was on the right, and on 50% of the trials when the light was on the left. There were eight trials per day; and the right-left sequences as well as the rewarded and non-rewarded left trials were randomly ordered. A self-correction procedure was used in the training.

All of the animals learned the problem, although most of them developed early position preferences for the right. After the animals had learned the discrimination, daily practice was continued until each animal had run a minimum of 7 consecutive days (or 56 consecutive trials) without error.

During the last several days of the post-learning performance period, several

important differences in the rats' behavior were noted, the most striking of which was the significantly greater running speed when the light was on the right (which was accompanied by reward on every such trial) than when the light was on the left (which was accompanied by reward on only half the trials). Examination of individual trial results discloses the fact that although the simple discrimination problem had been fully mastered and the time curves had apparently reached asymptotic limits, the running behavior was by no means static or fixed, but was varied in a systematic manner depending upon the results of the immediately preceding trial. It is suggested that a tentative explanation of the findings, pending further experimental attack, can best be made in terms of the "expectancy" point of view of Tolman.

(The assistance of Mr. Frank Giraffe in carrying out of this experiment is gratefully acknowledged.)

The Use of Galvanic Skin Response in Testing Pre-Published Advertising Copy. EDWIN GOLIN.

The advertising industry has been on the alert for methods of testing the effectiveness of pre-published advertising copy. Much time, energy, and money could be saved if methods were established that would diminish the uncertainties of such present devices as public opinion polls, experts' judgments, etc. Previous studies employing the galvanic skin response apparatus to test the effectiveness of advertising copy have been encouraging.

The present study was designed to answer the following question: Will the galvanic skin response significantly differentiate among different advertising layouts involving the same product? Three products were represented by four layouts each. The ads were then presented in a Latin-square type of order to a sample of 72 university students (60 men and 12 women). Analysis of the data indicated that there were significant galvanic skin response differences within each group of ads involving the same product and a difference in responses between male and female subjects.

Survey of Employee Attitudes in a Textile Mill. ORA M. JONES.

Problem: Discover through a quantitative-qualitative analysis of employee attitudes, the intensity and interrelation of factors which are related to degree of job satisfaction in a specific textile mill.

Population: The test group consists of 447, or 7[illegible]% of total mill employees.

Procedure: The method used is the interview-questionnaire type. This includes a free-answer guided interview of a sample of employees to determine areas of satisfaction and dissatisfaction; formulation of a multiple-choice questionnaire covering eight general areas, namely, Job Satisfaction, Supervision, Co-Worker, Working Conditions, Pay and Promotion, Training, Job Efficiency, and Management and factual data pertaining to the individual's background such as age, sex, etc.; pre-testing the questionnaire for mutual understanding of language; and the final administration of questionnaire in a group test situation to 358 and by mail to the remaining non-supervisory employees.

Results: Results of the quantitative-qualitative analysis are specific only to data obtained from this particular mill.

The Carding Department is significantly (significant at 1% level) lower in Job Satisfaction than the other departments, this dissatisfaction being expressed in all areas except Supervision and Pay.

A comparison of Job Satisfaction scores with various personal factors indicate that Job Satisfaction: a) increases with age up to 57 years, then decreases; b) increases with length of service; c) is inversely related to education; d) is significantly (at 1% level) higher for females; e) is not significantly related to home satisfaction. However, the younger employees with higher education in the Finishing Department and the older employees with less than fourth grade education in the Carding and Spinning Departments have the higher job satisfaction. Difference in sex is restricted largely to the Twisting and Winding Departments.

Conclusion: General conclusion is that the intensity and interrelation of variables relevant to job satisfaction are dependent upon their interaction with other factors both physical and psychological and no constant value can be assigned to a factor.

Three Piedmont Reservoirs. E. E. HUESKE.

A portion of the fisheries investigations conducted by the N. C. Wildlife Resources Commission during the summer of 1948 consisted of a fish survey of the Creedmoor, Monroe, and High Point city lakes. The primary purpose of this investigation was to determine the species of fish present, their relative abundance, and success of reproduction. This information was used as a basis for formulating a fish management plan.

Fish collections were made with the aid of gill nets and derris, 5% rotenone content. The gill nets were most effective in collecting coarse fish while the use of derris resulted in collections of a variety of sizes and species.

Creedmoor City Lake is the smallest of the three reservoirs considered. It was impounded in 1937 forming a reservoir 20 acres in size. In 1943 it was enlarged to 125 acres and again in 1946 to its present size of 200 acres. Eleven species of fish were collected including the chubsucker, yellow bullhead, bulldog pickerel, largemouth bass, warmouth, bluegill, pumpkinseed, green sunfish, black crappie, golden shiner, and top minnow. Although some stocking has been done in this lake, the fish population seemed to be the result of natural reproduction of the fish which were present in the stream when it was impounded. Pumpkinseeds were present in the greatest numbers. However, the weight of the chubsuckers and yellow bullheads was more than half of the total weight of all fish collected. The rate of reproduction had been high and regular in the black crappie and pumpkinseed, while it had been comparatively poor in the case of the largemouth bass, bluegill, and the other species collected. The management problem in the Creedmoor City Lake seemed to be that of establishing a bass population and reducing the number of crappie. More bluegills would be desirable but their increase would have to be dependent on natural conditions as the pumpkinseed were present in such large numbers. The addition of largemouth bass may give

satisfactory results, although this is doubtful because of the increasing number of crappie in the reservoir. If stocking with bass is not successful, it then would be necessary to drain the reservoir, destroy the undesirable fish, and stock on a balanced basis with largemouth bass and bluegills.

The Monroe City Lake was constructed in 1927 and is approximately 250 acres in size. Eleven species of fish were collected including the chubsucker, brown bullhead, channel catfish, chain pickerel, largemouth bass, warmouth, bluegill, pumpkinseed, robin, white crappie, and golden shiner. The pumpkinseed was by far the most abundant fish in the reservoir while the largemouth bass, bluegills, and crappie composed a comparatively small part of the fish population. The coarse fish population was not found to be excessively large. Reproduction was almost entirely lacking except in the pumpkinseed. This reservoir had been utilized very little for fishing and consequently the fish population was made up of many small fish with possibly a few large bass. The management of this reservoir involved harvesting more fish, concurrent with possibly the addition of largemouth bass in an effort to increase the average weight of the fish.

The High Point Municipal Lake is the largest of the three and was found to be in exceptionally good condition so far as the fish population was concerned. This reservoir was constructed in 1925 and is approximately 370 acres in size. The fish collections contained ten species including the yellow bullhead, white catfish, largemouth bass, warmouth, bluegill, pumpkinseed, robin, black crappie, golden shiner, and darter. The most abundant species were the largemouth bass and bluegill. Comparatively few crappie were found and almost no evidence of a coarse fish population was seen. Reproduction was satisfactory in the bass and bluegills and poor in the other species, which is a desirable situation. The rate of growth was plotted for the bass, crappie, and the bluegill. This showed a consistent growth although not unusually rapid. Because of the desirable fish population in this reservoir, the only recommendation was more fishing in order to increase the average size and weight of the fish.

It is to be noted that although these three reservoirs lie within the same geographical region and contain almost the same species of fish, each required an individual management plan because of difference in abundance of the various species of fish.

Speciation in the Field Cricket, Gryllulus assimilis *Fab.* B. B. FULTON.

The classification of the common field crickets of the genus *Gryllulus* (= *Gryllus*) has been the despair of students of American Orthoptera. Between 1775 and 1903 forty-seven New World species were described. The diagnostic characters were all extremely variable. In 1908 Lutz published a biometrical study of series from many parts of the United States and the collection of the British Museum, which included specimens from many parts of the world. Lutz concluded that no specific entities exist in the genus *Gryllus*. In 1915 Rehn and Hebard published a study of the genus in which they agreed with Lutz regarding the American field crickets but pointed out that Lutz overlooked characters of real specific value in the Old World species.

This work greatly simplified the task of identification by making it correct to

apply the binomial *Gryllus assimilis* Fab. to every specimen from Canada to Patagonia. The present study however shows that this is an over-simplification and that even within the limits of the state of North Carolina *G. assimilis* does not conform to the present day concept of a species as an interbreeding population.

In all northern states where the species has been studied, two single brooded seasonal races occur, one wintering as nymphs and the other as eggs. In North Carolina the writer has discovered four races which are distinguished by one or more physiological characters such as type of song, choice of habitat, or seasonal history. Under year-round laboratory rearing all of these races show a tendency to retain the seasonal history normal for the race. However, there was sufficient response to artificial conditions so that adults of two or more races were obtained at the same time.

When males and females of different races were paired, mating occurred and some eggs were usually laid but no offspring were produced. Observations and a few experiments seem to show a tendency on the part of males to mate with their own race when given a choice. Thus it is shown that these races are not only isolated by ecological distribution or time of maturity but are effectively prevented from crossing by some internal isolating mechanism which either prevents fertilization or the formation of a viable zygote.

Histological Observations on the Metamorphosis of Male Habrobracon. D. S. GROSCH.

Unlike the majority of holometabolous insects, the ectoparasitic wasp known in genetic literature as *Habrobracon juglandis* (Ashmead) does not accumulate a reserve in the form of a large fat body during the feeding period. Instead, the contents of the midgut lumen comprise 89% of the body volume when the larva spins itself into the cocoon. The chief structural changes in organs and appendages have been described for developmental stages (including those in the cocoon) by Seurat, Henschen, Schlüter and Hase in closely related if not identical materials. Attention in the present report is directed to such histological changes as are shown on serial sections, prepared from organism of known age, by the paraffin method.

In comparison with non-parasitic Hymenoptera (honey bee for example) a relatively long time elapses between spinning and the beginning of the pupal stage. During this preliminary period which amounts to over 50% of the time spent in the cocoon, there is an increase of the fat body in all regions through increases in individual cell size. Accompanying this there is a decrease in the midgut diameter with the cells of the larval gut wall changing from flattened pavemental to bulging columnar shapes. The fat cells grow in diameter from 60μ to over 100μ. In the abdominal region the fat cells persist into the imago while in contrast they disappear completely from the head and thorax regions during the elaboration of muscle and nerve materials. These elements are so greatly developed by the last day before eclosion that they have become the only visibly extensive histological materials in the thorax and head.

Thus it is shown that the braconid procedure differs from that more common to the insects in sequence rather than in the nature of events associated with the

utilization of the stored reserves. That is, the fat body has its greatest development *after* the quiescent period in the cocoon has begun instead of before the cocoon is spun. Nevertheless when the morphogenetic events do proceed, differences from general mechanisms reported in other Hymenoptera have not been observed. This includes disorganization and disappearance of the larval midgut, spinning glands, and Malpighian tubules, presumably to provide reserves supplemental to those available through the partial disintegration of the fat body.

The Inheritance of Ectrodactylism; a Preliminary Report. C. D. HOWELL and T. S. BARRINGER.

Fifteen cases of ectrodactylism have been discovered in one county. All cases are related to one man, Jacob, who came to America before 1750. Most of seven generations of his descendants have been traced in this study. The physical manifestations of the defect are typical of what can be found in the literature.

Eight of the cases can be traced also to two other early settlers, Mark and Solomon, both of whom are believed to have come from the same region of Germany as Jacob and at the same time. Considerable inbreeding has occurred among the descendants of these three, and the possibility of their being related is being investigated.

Ectrodactylism is generally found to be a dominant. In the present study, however, it is concluded to be due to an autosomal recessive gene. Affected cases are spotty in the genealogy. There is considerable inbreeding. Ectrodactylic fathers had twelve children by normal wives, and all children were normal. The affected persons had a total of 42 normal sibs, making an almost perfect ratio of 3 normals to 1 affected, as would be expected if both parents were heterozygous.

Work is being done to establish more connections in the family and also to connect this pedigree with three other pedigrees of ectrodactylism in the literature.

Parasitic Crustaceans from Bimini. A. S. PEARSE.

From 368 fishes of 73 species 290 parasitic copepods and 9 isopods were collected. Of the 25 species of copepods, 14 in the following genera were new: *Anuretes* (1), *Caligus* (3), *Lernanthropus* (4), *Hatschekia* (4), *Nemesis* (1), and *Cybicola* (1). From shrimps and crabs 8 species of parasites were secured. New species were found in the following genera: *Leidya* (1), and *Octalasmis* (2).

The Circulatory System of Conjoined Twin Calves. W. O. PUCKETT.

A description was given of the circulatory channels found in full-term conjoined twin calves. The animals described showed a fusion of the head and thoracic regions, a condition known as cephalothoracopagus.

Some Comments on the Study of Myrmecophiles. M. W. WING.

A definition of the term *myrmecophile* was given so as to include only those forms which actively seek out the ants. The myrmecophile-ant relationship is then a passive one from the standpoint of the ants. The number of known myrmecophilous forms is large. Also they are extremely varied, not only structurally, but also in the degree to which they have become adapted behavioristically to living

with ants. Degrees of specialization among myrmecophiles were discussed, using the order Coleoptera as an example. *Quedius* and *Atemeles* were cited as examples of a generalized and a specialized myrmecophile respectively. In the light of the large number of known myrmecophilous species, one is forced to the conclusion that ants' nests must have a great attraction for terrestrial arthropods. The greater degree of protection and amount of food available in the formicary may explain this fact, at least in part. The question naturally arises as to why the ants are so easily exploited by the myrmecophiles, which may be considered social parasites. The answer seems to be that the rather rigid devices of food, odors, textures, etc., which normally hold the ant colony together, are rather easily exploited by the more highly specialized myrmecophiles, as the behavior-patterns of the ants are not especially plastic.

An estimate of the number of known species, subspecies, and varieties of myrmecophiles has been given by various writers. Three of these estimates are especially noteworthy. They are: P. E. Wasmann (1894), 1224; W. M. Wheeler (1910), 1500 and H. Donisthorpe (1927), 5000. These figures might possibly be viewed as underestimates; two interpretations were discussed: 1) New forms are constantly being described from all areas. For example, I have recently found a new genus and species of myrmecophilous Diapriid and also a new species of the Phorid genus *Ecitomyia* (ecitophile) in North Carolina. 2) In already named animals, there is something of a tendency to discover myrmecophilous habits, as we learn more about their ecology. *Arachnophaga aldrichi* Gahan is a case in point. The facts were discussed which lead me to believe that this myrmecoid Eupelmid is a myrmecophile. However, one might discover factors to indicate that the figures are overestimates. For example, many of the forms listed in the literature as myrmecophiles often have no real relationship with the ants. Such forms are often found in ants' nests by Berlese Funnel or breeding methods, but their association with ants, if it exists, may be fortuitous. I pointed out that the term "ants' nest" has little meaning in this connection, as a very high percentage of the nest material is not normally in contact with the ants. It is thus usually necessary to study a supposed myrmecophile in an artificial nest with the ants in order to determine its status.

A good estimate of the number of described myrmecophiles in the world would require first an exhaustive compilation from the literature. Second, critical judgment would have to be exercised if only myrmecophiles were to be included. Upon the completion of my catalogue of the ants and myrmecophiles of the world, I propose to attempt such an estimate. At present purely as a guess, I suspect that Mr. Donisthorpe's figure of 5000 may be about right for the described myrmecophiles. An attempt to guess the total number of myrmecophiles (described and undescribed) would be futile; but such a figure would doubtless be many times greater than 5000, as the tropics, which are especially rich in new species have been very inadequately investigated to date.

*A Preliminary Report on the Use of Chick Embryonic Extract in the Culture of Amphibian Pigment Cells.** H. E. LEHMAN.

* Aided by a grant from the Smith Research Fund of the University of North Carolina.

Isolation techniques have proved to be particularly rewarding in the analysis of problems relating to Amphibian pigmentation. A standard method for the preparation of hanging drop cultures of Amphibian pigment cells has been described by Twitty (1945, J. Exp. Zool.) who reported the use of two media: namely, Holtfreter's standard salt solution and peritoneal fluid obtained from adult spawning newts. The latter medium has proved to be more favorable than physiological salt solutions for the differentiation of both melanophores and xanthophores in vitro. Unfortunately the quality of the fluid obtained from different animals exhibits considerable variability and this, along with the inability of always being able to obtain adequate amounts of fresh fluid when needed, make it desirable to find a substitute which would duplicate the favorable culture properties of peritoneal fluid.

Promising results along this line have been obtained from preliminary experiments in which *Amblystoma tigrinum* and *A. punctatum* pigment cells were cultured in physiological salt solutions to which chick embryonic extract was added. The extracts were prepared as follows: 4 6-day embryos, with eyes removed, were macerated in 10 cc of standard salt solution by forcing them through a fine wire grid placed at the bottom of a 10 cc syringe. The tissue brei obtained in this manner was centrifuged and the supernatant (sealed in ½ cc Pyrex ampules) was stored at 6°C. until used. Throughout the preparation, sterile precautions were observed.

Six test series have been carried out, each consisting of 20 neural crest explants in physiological salt solution, peritoneal fluid, and various dilutions of embryonic extract. The rate and degree of pigmentation obtained in media containing embryonic extract were appreciably higher than that encountered in salt solution, and in the main they compared quite favorably with the results obtained with peritoneal fluid. The degree of melanization found in the *best* cultures in peritoneal fluid was not achieved with embryonic extract; however, the differentiation of xanthophores in the latter media was very striking and appeared to be as complete as that observed under the most favorable circumstances with peritoneal fluid. The highest level of pigmentation in the experimental series was obtained when ½ to ⅔ dilutions of stock extract were used. Higher concentrations of extract appeared to inhibit the outgrowth of pro-pigment cells from the explant. Dilutions as low as 1 part stock extract to 6 parts salt solution gave visibly better chromatophore differentiation than Holtfreter's solution alone. No direct comparison has been made between the culture properties of fresh and stored extract; however, very satisfactory pigmentation was observed in one series in which 6 week old stock extract was used.

Supplementary tests and experiments are needed to test and standardize this media; however, even now it is evident that a reasonably satisfactory substitute for peritoneal fluid can be found in the use of chick embryonic extract as a culture medium designed to foster high degrees of differentiation in Amphibian pigment cells in vitro.

REINARD HARKEMA, *Secretary*.

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY

1948–1949

466th Meeting, October 12, 1948

S. Y. Tyree, Jr. (Chemistry): *Potassium Peroxyselenate.*

Evidence was presented in support of the existence of a potassium salt of a peroxyselenic acid. Dry potassium hydrogen selenate crystals were fluorinated. The product exhibited some oxidizing power and, on hydrolysis in hot acid solution, some reducing power. The yield was no more than five per cent in any experiment. Nevertheless, such behavior can be logically ascribed to a peroxy compound only. It is believed that such peroxyselenates (if they do exist) are very unstable in wet air and must be prepared in the absence of water. The formula assigned to the compound is $K_2Se_2O_8$. Eight references to previous literature were given.

W. A. White (Geology): *Drainage Modifications in the Piedmont of North Carolina and Virginia.*

H. R. Totten, chairman of a special committee appointed to consider awards and honors, reported the recommendations of his committee as follows:

1. That the Elisha Mitchell Scientific Society do honor to the memory of Francis Preston Venable by adding to the cover and title page of each future issue of the *Journal* the statement: This society was organized in 1883 through the efforts of Francis Preston Venable

2. That the Elisha Mitchell Scientific Society shall award each year a prize, to be known as the William Chambers Coker Award in Science, to the graduate student whose thesis or dissertation shall be adjudged the best submitted in the science division during the year.

3. This prize shall consist of a properly inscribed certificate announcing the award and fifty dollars ($50 00) in cash; the prize shall be delivered to the recipient, if possible, at the May meeting, and the recipient shall be offered a place on the program at that meeting of the Society; and the name of the recipient and title of the thesis or dissertation shall be placed on the commencement program.

4. The recipient of the award shall be selected in the following manner: Each scientific department may submit to a judging committee of this society the thesis or dissertation which the faculty of said department consider most worthy of those received since the previous award. Such recommendation and thesis or dissertation must be received by the judging committee by May 1.

5. The judging committee of the Society shall consist of the following: The Chairman of the Science Division of the University, and two other members selected by him.

J. B. Bullitt
Wm. deB. MacNider
H. R. Totten, *Chairman*

The above recommendations were unanimously adopted.

467TH MEETING, NOVEMBER 9, 1948

H. E. LEHMAN (Zoology): *The Relationship of Donor and Host Developmental Rates to the Suppression of Pigmentation in Salamander Larvae.*

Recent studies have shown that Amphibian pigment cells which possess either an advantage in age or in rate of development are able to inhibit the differentiation of younger or less rapidly differentiating pro-pigment cells. The experiments to be reported were undertaken for the purpose of further examining this correlation. These experiments involved explantations and transplantations of neural crest and neural folds of 3 species of *Amblystoma* and 2 species of *Triturus*. These species listed in the order of increasing rates of development are: *T. rivularis, T. torosus, A. punctatum, A. mexicanum, A. tigrinum.*

When unilateral orthotopic transplantations of neural folds were made in all possible donor-host combinations between these species, it was found that the optimal condition for obtaining the most striking manifestation of pigment suppression was obtained when a relatively large, but not necessarily a maximal, difference existed between the developmental rates of donor and host chromatophores (e. g., when *T. torosus* or *T. rivularis* were combined with *A. mexicanum*). Observations on the experimental animals during the course of larval development revealed that the inhibition of pigmentation in the more slowly developing pro-pigment cells was not permanent. Though considerably delayed in their development, the slowly developing cells eventually became pigmented in appreciable numbers during late larval stages. Suppression of pigmentation of the type encountered here, accordingly, should be considered a temporary phenomenon confined largely to late embryonic and early larval periods.

Additional experiments were carried out in an attempt to expose the nature of the interactions between chromatophores of different age or rates of development which are responsible for delaying pigmentation in younger or more slowly developing pigment cells. To this end, pieces of neural folds were introduced into hanging drop cultures possessing established outgrowths of chromatophores 4 to 10 days old. It was observed that when the younger and older outgrowths differed only moderately in age, there was very little mixing of cells when the two outgrowths came in contact with one another. A fully differentiated (10-day) primary outgrowth, on the other hand, was readily overgrown by cells emigrating from a younger explant. Essentially similar results were obtained when *A. punctatum* neural crest was grafted onto the flank of *T. rivularis* hosts of graded age. On hosts of intermediate age (in which *rivularis* pro-pigment cells were partially differentiated on the flanks at the time of operation) *punctatum* melanophores did not invade the flank regions occupied by host cells. However, on older *rivularis* hosts, donor cells were able to populate the flanks and were found intermingled among fully differentiated host cells.

These results are taken to mean a) that pigment cells in the active process of differentiating are able to impede the migration of less mature cells more effectively than are fully pigmented cells, b) that if given an optimal intermediate advantage in age or rate of development, one group of pro-pigment cells will be able to prevent or delay the outgrowth of other chromatophores, and accord-

ingly c) that the degree of suppression manifested in a given instance might be directly correlated with the magnitude of difference existing between the developmental rates of donor and host pigment cells.

WILLIAM DEB. MACNIDER (Pharmacology): *Concerning the Inability of 2,3 Dithiopropanol* (BAL) *to Prevent or to Modify the Acute Renal Injury Induced by Uranium Nitrate.*

2,3 dithiopropanol (BAL) in one of a large number of chemically closely related bodies that have been developed in an attempt to find a substance which would so influence tissues as to modify the toxic action of a variety of injurious agents and primarily for gaseous substances containing arsenic. The above indicated chemical body acts with a high degree of efficiency both in preventing and relieving tissue toxicity of both arsenic bearing compounds and of bichloride of mercury.

Uranium nitrate is one of the heavy metals which acts as a toxic agent for the kidney and exercises this influence in a predominant fashion in the same segment of the renal nephron that is elected by bichloride of mercury to express its toxic influence. With this fact in mind experiments of three types were undertaken to ascertain whether or not 2,3 dithiopropanol given in the amount of 15 mgm. per kg. to dogs subcutaneously would prevent the development of the toxic action of uranium or modify or relieve it after it had developed. The three types of experiments employed were: (1) To administer to animals 15 mgm. per kg. of this substance twice a day for four days and then attempt to intoxicate the animal with 4 mgm. per kg. of uranium nitrate, the substance being given subcutaneously. (2) To induce a uranium intoxication in the dog with 4 mgm. of uranium nitrate per kg. and then attempt to modify it by the subcutaneous use of 15 mgm. of 2,3 dithiopropanol given twice a day for four days. (3) To combine these two methods of procedure to give to the third group of animals the 2,3 dithiopropanol for two days, then intoxicate the animals with 4 mgm. of uranium nitrate per kg. and then to continue the use of the protecting substance for two days after the uranium nitrate injury has established itself.

These three types of experimental procedures have indicated that the use of 2,3 dithiopropanol has no effect in preventing the toxic action of uranium nitrate or of modifying it after it has developed. Furthermore, when this substance was given before the use of uranium nitrate there is both structural and functional evidence that it intensifies the ability of uranium nitrate to injure the kidney. It would, therefore, appear that the use of 2,3 dithiopropanol has a sensitizing influence over the kidney which increases the toxic action of uranium nitrate and, in addition, the use of this substance in uranium intoxication, even though the injury from uranium is at the same site in the kidney as the toxic action of bichloride of mercury, has no protecting or remedial influence against the uranium intoxication, whereas it is very definitely effective in bichloride intoxication. It would, therefore, appear that the uranium intoxication which dominates in the proximal convolution of the renal nephron is brought about by an intracellular chemical mechanism different from that which is induced by the use of bichloride of mercury.

468TH MEETING, DECEMBER 14, 1948

EARLENE ATCHISON (Botany): *Cytological Studies in the Leguminosae.* (Published in this Journal, **65:** 118–122, 1949)

A. HUGHES BRYAN (Public Health) and B. G. GREENBERG (Institute of Statistics): *Methods for Studying the Influence of Socio-Economic Factors on the Growth of School Children.* (Published in this issue.)

469TH MEETING, JANUARY 11, 1949

A. V. MASKET (Physics): *The Measurement of Forces Resisting Armor Penetration at Ballistic Speeds.*

This paper summarizes the experimental and theoretical status of the optical chronograph developed in the course of ballistic research at the Naval Research Laboratory. The instrument, together with a simple procedure for analysis of data, is capable of yielding the position, velocity, and deceleration of a non-plastically deforming small arms projectile during the armor penetration process, which lasts from 30 to 150 microseconds. Decelerations have been observed up to 5×10^7 ft./sec.^{2} The longitudinal vibrations induced in projectiles during impact were observed by a shadow-photography technique which yields time-displacement curves from the motion of the trailing face of a projectile during penetration. The precision of the derived decelerations, about 4 per cent, is sufficient to permit the evaluation of strain-rate and inertia effects during high speed indentation by means of conical indenters at strain-rates approaching 2×10^5/sec.

H. D. BRUNER (Pharmacology): *Air Flow in Endotracheal Tubes.*

The pressure-volume flow relations of assorted endotracheal catheters were determined for the purpose of providing a means whereby the anesthetist or surgeon might select the optimum tube for the conditions in hand. These conditions include: (a) The maximum instantaneous air flow to be encountered under existing conditions in that subject. It was emphasized that there is at present no way to predict accurately what this figure is except very roughly as between 2 and 4 times the individual's minute volume. (b) The maximal negative inspiratory and positive expiratory intrapulmonary pressures which the operator considers safe. Excessive pressure of either type is definitely damaging to the lung and cardiovascular system and may be fatal. The data provide, therefore, a partial answer to the requirement in endotracheal intubation of adequate instantaneous air flow levels together with minimal trauma to the larynx as produced by increasing size of catheter.

470TH MEETING, FEBRUARY 8, 1949

K. M. BRINKHOUS (Pathology): *Some Observations on Canine Hemophilia.*

A strain of dogs with a hemorrhagic disease similar to hemophilia in man was described by Field, Rickard and Hutt in 1946. This sex-linked disease appears to have arisen as a mutation. We obtained this strain of dogs for further study. In

15 litters from the mating of heterozygous females and normal males, 35 of 62 male progeny were affected with the bleeding tendency. None of the females were bleeders. Six of eleven females tested for the heterozygous state were positive. These distributions for each sex are close to the 1:1 ratio which would be expected in a sex-linked type of inheritance.

Heretofore, affected males have died of hemorrhage in early life. Transfusions of normal blood or plasma temporarily reduce the prolonged clotting time of these animals to a normal or nearly normal range. Concomitantly, the bleeding tendency is corrected. By using transfusions during hemorrhagic episodes, fatalities have been almost completely eliminated and bleeder dogs have been reared to maturity.

Considerable variations in the severity of the bleeding tendency have been observed. Animals with a severe form of the disease bleed frequently into joints and subcutaneous tissues. In spite of repeated transfusions, permanent joint deformities and crippling have occurred. In the milder forms of the disease, no conspicuous joint deformities were observed.

Comparative studies of the clotting defect in canine and human hemophilia revealed no fundamental differences in the two diseases. Both appear to be due to a deficiency of a plasma protein which normally interacts with blood platelets to make thromboplastin available for the clotting reaction.

W. M. WHYBURN (Mathematics): *Critical Points for Function.*

Long before the discovery of the calculus, scholars recognized the importance of "critical" or "exceptional" points in all of their efforts to find and understand the laws of nature. It was seen that the occurrences of nature are in keeping with clear-cut principles which, if fully understood, would be *maximal* or *minimal.* The natural course of a river, the eventual shape of a pebble in a stream of water, the path of a planet or an electron, and countless other phenomena can best be interpreted in terms of maximizing certain quantities while either holding others constant or minimizing them.

Discovery of the calculus provided mathematical means for better describing and studying these critical phenomena. The basic laws are formulated as functions of one or more independent variables and these functions studied through use of the differentiation and integration processes. When the functions are continuous and have derivatives at each point of the range of the independent variables, the critical points of the functions occur where all of the first derivatives vanish. In the usual treatments, the functions are required to have derivatives of the second and third orders in neighborhoods of the critical points and, through non-vanishing requirements on the second derivatives, the number of critical points in a bounded portion made finite. Under these hypotheses, the functions are expanded in a Taylor's series with the remainders expressed as terms of the second order—such expansion being made in a neighborhood of each critical point. The quadratic form thus obtained is transformed into one which involves only square terms and this new form used to classify the critical points in $(n+1)$ types, where n is the number of independent variables occurring in the function.

Relations between the numbers of critical points of the different types are then established and these used to prove the existence of critical points whose discovery had not otherwise been made. Such existence results have been important factors in searches for new chemical elements, new planets, and new information about atomic structure.

The present paper characterizes critical points and studies these for functions which are assumed continuous but which are not required to possess any derivatives. The critical points may be infinite, non-isolated, and may group themselves into continua called "critical sets". Critical sets of four types are identified and relationships between the numbers of sets of these types are established.

471ST MEETING, MARCH 8, 1949

C. T. KAYLOR (Anatomy): *Specialized Tissue in the Human Heart.*

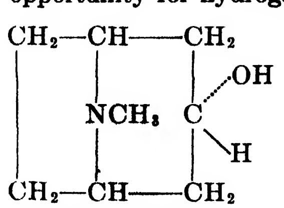
Recent work has aroused serious doubt as to the existence of any specialized tissue in human and some animal hearts. In serial sections of five young human hearts, we could see no justification for the above claims. Specialized tissue (atrio-ventricular bundle) was found to exist in all our sections. Its morphology conformed roughly to older descriptions. We found in addition many new branches of this tissue not hitherto described and in addition atrio-ventricular connections which on an anatomical basis could account for some of the modern heart syndromes.

W. H. HARTUNG (Pharmacy): cis- and trans- *TROPANOL.*

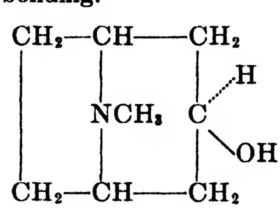
Tropanol is obtained by the hydrolysis of atropine, and pseudo-tropanol is obtained by the hydrolysis of tropacocaine. These tropanols are optically inactive but they are *cis-trans* isomers. On oxidation, in each, of the alcohol hydroxyl group, they form the same ketone, tropanone. Tropanone may be reduced depending on conditions, to either tropanol or to pseudo-tropanol.

Tropanone may be obtained also by Schöpf's modification of Robinson's "elegant" synthesis. Succinaldehyde, methylamine and acetonedicarboxylic acid, in solution and under "biological conditions", condense spontaneously to form good yields of tropanone. Reduction of tropanone with platinic oxide forms pure tropanol; reduction with sodium and ethanol forms only pseudo-tropanol.

A study of molecular models of the two isomers suggests that for the isomer in which the hydroxyl group is *cis* to the -NCH_3 bridge there may be expected a greater hindrance mutually between the alcoholic and amino functions; there is also greater opportunity for hydrogen bonding.



trans-Tropanol



cis-Tropanol

It would be expected, therefore, that the properties of the two isomers should be significantly different; e. g., the *cis*- ought to be a weaker base and its rate of esterification should be slower.

It was found experimentally that pseudo-tropanol, when the isomers are titrated, is the weaker base and, in a given length of time, forms a lesser yield of ester. Hence, the *cis*-configuration is assigned to pseudo-tropanol. In harmony with this conclusion are two other observations: the *cis*-isomer, in which the -OH and $-NCH_3$ are in closer proximity, is less hydroscopic and has a higher melting point.

The significance of this isomerism is indicated by the facts that the mandelic ester of tropanol (*trans*-) is strongly mydriatic and the benzoic ester is less anesthetic; the mandelic ester of pseudo-tropanol (*cis*-) is a weak or inactive mydriatic and the benzoic ester is a potent local anesthetic.

472ND MEETING, APRIL 12, 1949

WAYNE A. BOWERS (Physics): *The Frequency Spectrum of Crystals.*

In order to calculate the thermodynamic properties of an ideal crystal, it is necessary to know the distribution of its natural frequencies of vibration. Born and von Karman have shown how these frequencies may be calculated, but mathematical difficulties have prevented the derivation of an explicit formula for the frequency distribution except in the case of a linear chain of atoms. In recent years various approximate methods of calculating this distribution have been proposed. Blackman and others have used the distribution found numerically from a small sample of the natural frequencies; Montroll has used a method which approximates the actual distribution on the basis of the averages of various powers of the frequencies, which may be found explicitly from the Born-von Karman equations; and recently Houston has used an approximation based on the distribution of frequencies corresponding to vibrations travelling in certain particular directions in the crystal. We have derived a formula for the distribution of frequencies of the transverse vibrations of a plane square lattice, including nearest and next-nearest neighbor interactions. Although this has no direct physical interest, it is useful as a test of the various methods of approximation which have been proposed. We find that while the methods of Blackman and Montroll give fairly good approximations, Houston's method may give spurious peaks in the distribution which distort its shape considerably.

JOFFRE COE (Anthropology): *The Evolution of Aboriginal Cultures in the Carolina Piedmont.*

473RD MEETING, MAY 10, 1949

A. F. CHESTNUT (Institute of Fisheries Research): *Some Studies of the Digestive Enzymes of the Oyster* (*Ostrea virginica*).

Qualitative and quantitative studies were made to determine the presence of hydrolytic enzymes in extracts of the digestive diverticula, crystalline style,

masses of phagocytic cells and in filtered stomach contents of the eastern oyster. Amylolytic activity was found in all extracts with the greatest concentration in the crystalline style. Extracts of digestive diverticula and masses of phagocytic cells contained proteolytic and lipolytic activity. Proteolytic activity in general was slight. No demonstrable proteolytic or lipolytic enzymes were found in the crystalline style extracts. The presence of strong amylolytic enzymes suggests the capacity of the oyster to utilize materials rich in carbohydrates.

Dr. J. W. Lasley, Jr., *ex officio* chairman of the Committee on Awards, announced that the first winner of the William Chamber Coker Award was Dr. Earl B. Gerheim of the Department of Physiology, University of North Carolina Medical School.* Dr. J. H. Ferguson introduced Dr. Gerheim, who had flown down from Detroit to receive the award and to present his paper.

EARL B. GERHEIM (Physiology): *Staphylococcal Coagulation and Fibrinolysis.*

The classic demonstration of staphylococcal coagulation is credited to Leo Loeb (1903). Subsequent work showed that this clotting phenomenon was not mediated through the activation of prothrombin, but the basic mechanism awaited solving until Smith and Hale (1944) suggested that the staphylococcal product was the precursor (*prostaphylocoagulase*) of the active clotting agent (*staphylocoagulase*). These workers postulated that plasma contained an activator substance (*co-factor*) for *prostaphylocoagulase*, but did not identify the activator substance. The bacterial product used in our studies was prepared by modifying Tillet and Garner's (1933) technic for preparing *streptokinase*. Gerheim and Ferguson (1947) found this *co-factor* largely associated with the albumin fraction by use of ammonium sulfate fractionation technics; this was confirmed by Kaplan and Spink (1948), who in addition showed that the co-factor was associated with the globulins when alcohol was used in the fractionation.

Our next problem was to explain the incoagulability of some plasmas. This was found to be due to, (1) an inhibitor(s) which at least in part was directed against *staphylocoagulase*, (2) low *co-factor* content plus *inhibitor(s)*, and (3) *proteolysis*. No pure case of *co-factor* lack, as postulated by Smith and Hale, was found.

Early in our studies it was noted that fibrinolysis or fibrinogenolysis resulted only in the presence of a known plasma or serum proenzyme. This suggested that staphylococcal coagulation and proteolysis were distinct phenomena. Heat lability studies showed that heating at 75°C. for two hours completely destroyed the *prostaphylocoagulase* while the factor concerned in proteolysis was little altered in its activity. The latter factor we have designated *staphylokinase*. Lack (1948) reached similar conclusions as to the occurrence of the factor *staphylokinase*.

Streptokinase is highly specific for a proenzyme found in human plasma or serum. *Staphylokinase* activates a protease precursor of rabbit, guinea pig and

* Present address: Wayne University College of Medicine, Department of Physiology and Pharmacology, Detroit, Michigan.

dog plasma or serum, in addition to that of the human. *Staphylokinase* differs from *streptokinase* in requiring an incubation period ranging from 15–30 minutes for the development of maximal proteolytic activity.

Staphylocoagulation may be summarized as follows:

1. *Prostaphylocoagulase* + *co-factor* = *Staphylocoagulase.*
2. *Staphylocoagulase* + *Fibrinogen* = *Fibrin.*

Summary of staphylococcal proteolysis:

1. *Proenzyme* + *Staphylokinase* = *active enzyme.*
2. *Active enzyme* + *fibrinogen or fibrin* = *fibrinogenolysis or fibrinolysis.*

The Treasurer gave his report for the fiscal year, ending May 1st, and E. A. Brecht, Chairman of the Auditing Committee, said that the books had been examined and found to be correct. The report was adopted unanimously.

Dr. J. H. Ferguson, reporting for the Nominating Committee, presented the following:

President (one year)—HAROLD HOTELLING (Mathematical Statistics).
Vice-President (one year)—J. B. GRAHAM (Pathology).
Recording Secretary-Treasurer (two years)—A. E. RADFORD (Botany).

The above officers were unanimously elected.

L. L. GARNER, Sec.-Treas.

STUDIES IN THE COMPARATIVE ANATOMY OF THE CORNACEAE

By J. E. Adams

Department of Botany, University of North Carolina
Chapel Hill, North Carolina

The family Cornaceae offers a number of interesting problems to the systematist, both as to the relationships among its constituent genera and to its affinities with other families. Currently the family is considered to include the genera *Torricellia, Helwingia, Aucuba, Kaliphora, Cornus, Corokia, Lautea, Melanophylla, Griselinia, Mastixia, Curtisia.*

Bentham and Hooker (1867) excluded *Helwingia* which was placed in Araliaceae, but included *Alangium, Nyssa, Garrya; Lautea* and *Melanophylla* were published subsequent to 1867. Harms (1898) included all the above genera, except *Lautea*, and also *Davidia* and *Camptotheca*, grouping them in seven subfamilies. Four of these are now considered to constitute in whole or in part three distinct families, *viz:* Garryaceae, Nyssaceae, Alangiaceae. The three remaining subfamilies, *viz:* Mastixioideae, Curtisioideae, Cornoideae compose the family Cornaceae in the sense of Wangerin (1910), who divides Cornoideae into four tribes: Torricellieae (gen. *Torricellia*), Helwingieae (gen. *Helwingia*), Corneae (gen. *Aucuba, Kaliphora, Cornus, Corokia*), Griselinieae (gen. *Griselinia, Melanophylla*). *Mastixia* constitutes the subfamily Mastixioideae, *Curtisia* the subfamily Curtisioideae. Engler (1930) transfers *Corokia* to Saxifragaceae.

The family Cornaceae is traditionally allied with Nyssaceae, Alangiaceae, Araliaceae, and Umbelliferae in the order Umbellales. This alliance is based chiefly upon the few-carpeled and inferior ovary, reduced calyx, and a marked tendency toward a many-flowered, "umbellate" inflorescence. Within this order the family Cornaceae is considered the oldest by Wangerin. He regards the development of secretory ducts in the subfamily Mastixioideae a mark of relationship with Araliaceae and Umbelliferae strong enough to suggest a common ancestor for these families similar to *Mastixia*. Harms and Wangerin recognize an extraordinal relationship of Cornaceae with the shrubby Caprifoliaceae and suggest that they may have been derived from the same primitive stock. Wangerin further suggests an ultimate origin for Cornaceae in Rosales. Bessey (1915) proposes a phylogenetic treatment in essential agreement with the above. Hutchinson (1926), however, suggests the derivation of the woody Umbellales from Celastrales chiefly, and possibly also from Hamamelidales. Others have also proposed a strong celastralean relationship or have suggested that Cornaceae are not so closely allied with Araliaceae, Umbelliferae, etc., as commonly supposed. This is further suggested by the recent use of the ordinal name Cornales to include the woody Cornaceae and Nyssaceae. The varied history of the family as to generic constitution as well as the various suggestions as to phylogenetic position make the family and its presumed allies of considerable interest.

It would appear desirable, therefore, to approach the problem from another

viewpoint. It is the purpose of the present series to report the results of systematic studies on wood anatomy in a number of families, with the primary aim of evaluating the phylogenetic positions of Cornaceae and its presumed allies. The geographic distributional aspects of the broad problem are to be dealt with subsequently.

Preliminary, however, to such evaluation and the proposal of lines of interfamilial relationship, a detailed consideration must be given to the constitution of the families involved. Considering the range of anatomical variation frequently encountered within a single family, it is important that all genera and a large proportion of the species be studied, for only thus can a significant evaluation of the family be had. The sum of the known morphological data and that derived from anatomical study should make possible a more complete understanding of the phylogenetic position of the family and of its constituent genera. The function of the anatomist in problems of this sort is conceived to be twofold. First, the systematic analysis of the members of the family with a view to providing more complete knowledge of the structure of the plants makes possible the more precise definition of taxonomic units. Second, the recognition of evolutionary trends in anatomical characters provides an independent scale by which evolutionary progress of a family may be measured. Insofar as phylogenetic systems arrived at by gross morphological and by anatomical studies are in close agreement, the former is strengthened and the latter validated. Discrepancies may be expected, for it cannot be assumed that the pace of evolutionary change will be the same in all characters. Such disagreements are to be resolved by careful evaluation. That is to say, anatomical data must be considered adjunctive to gross morphology and not a substitute therefor. The value of evidence gained from wood anatomy toward the elucidation of some puzzling phylogenetic problems has been well illustrated by the work of Cox (1948, 1948a) on Ericaceae, Garratt (1933) on Myristicaceae and (1934) on Monimiaceae, and by others.

The basic studies by Bailey and Tupper (1918) and by Frost (1930, 1930a, 1931) reveal the evolutionary trends in the development of the vessel element in the secondary xylem of dicotyledons. Thus primitive vessel elements may be characterized by the following features:

1. great average length
2. small cross-sectional diameter
3. angular outline in cross-section
4. thin, even walls
5. end wall not distinct, or highly inclined to transverse axis
6. scalariform perforations with many bars
7. fully bordered scalariform pits in side wall
8. wall without tertiary thickening;

while the highly specialized elements exhibit:

1. small average length
2. large diameter in cross-section
3. circular cross-sectional outline
4. thick, uneven walls

5. distinct end wall of low inclination, or parallel to transverse axis
6. simple porous perforations
7. round, alternately arranged side wall pits with greatly reduced borders
8. tertiary wall thickening.

Between these extremes all conditions of transition may be recognized. Thus, for example, the transition from the many-barred scalariform perforation to the simple porous perforation was effected by the gradual reduction in number of bars and increase in size of apertures. Similarly, the modification of side-wall pitting from scalariform to round alternate produced, in order, intermediate types which may be described as elongate-elliptic opposite, and round opposite.

Gilbert (1940) concludes that the diffuse-porous condition of the secondary xylem is phylogenetically primitive and gave rise to the ring-porous condition. Likewise, the diffuse arrangement of xylem parenchyma is regarded as primitive, while the meta- and paratracheal arrangements are specialized.

Kribs (1935) recognizes six fundamental types of medullary rays with the Heterogeneous series primitive and the Homogeneous series derived.

Tippo (1938) and others have recognized septation of fibrous elements as a mark of specialization.

It is not to be expected that any one family will show a full range of expressions from the most primitive to the most specialized in each of the evolutionary lines. Moreover, it is not likely that evolutionary advance will necessarily proceed at a uniform rate in all such lines. Thus among the diverse and widely spread genera of Cornaceae considerable variation in wood structure is found, but the most primitive expressions within the family are not the equivalent of the most primitive expressions known. That is to say, the family shows a definite range of expression in the several phylogenetic lines; the upper and lower limits of such ranges can be determined and the genera thus placed in their appropriate relative phylogenetic positions within the family. From the same data an overall evaluation of the phylogenetic position of the family may be had with reference to related families.

MATERIALS

All genera of Cornaceae are represented in the present stu y: *Mastixia*, 7 species; *Curtisia*, 1; *Helwingia*, 3; *Griselinia*, 4; *Melanophylla*, 1; *Torricellia*, 1; *Corokia*, 2; *Lautea*, 1; *Aucuba*, 3; *Kaliphora*, 1; *Cornus*, 30. In the genus *Cornus* all subgenera, sections and subsections (except subsect. Oblongifoliae), according to Wangerin's treatment, are represented. A total of 146 specimens of well developed secondary wood was examined. These were obtained in large measure from the extensive wood collection of the Yale School of Forestry (Y) through the kindness of Dr. Robert W. Hess, from the Herbarium of the New York Botanical Garden (NY), The United States National Herbarium (US), the Herbarium of the University of North Carolina (CNC), Musée Nationale d'Histoire Naturelle, Paris (P), through the kindness of Dr. J. Leandri, and the author's personal collections.

Wood specimens were softened for sectioning by soaking in water at 60° C

(to which a few drops of Tergitol were added) for one to five days. Appropriate transverse, radial and tangential sections, cut approximately 20μ in thickness, were used for data on wood type, medullary ray type, vessel cross-sectional outline, vessel wall thickness, vessel side-wall pitting, angle of vessel end wall, tertiary vessel-wall thickening, wood parenchyma pitting. Macerations were prepared in the usual way with Jeffrey's fluid after preliminary softening with Tergitol. Safranin-stained macerations supplied data on vessel perforation, vessel diameter, vessel length, fibrous elements, fiber septation.

Numerical data, such as vessel length, vessel width, number of bars per scalariform perforation, and vessel end-wall angle were obtained from 100 readings taken from 10 or more slides. These are recorded as averages for the species, for many of which more than one specimen was studied. Averages for genera or sections were computed from those of their constituent species. Descriptive terminology conforms to commonly accepted standards.

ANATOMICAL SUMMARY FOR THE FAMILY

A number of structural features of the secondary wood are recognized for their significant variations and diagnostic value. These are listed below, with a brief statement of the family characteristic for each.

1. *Wood type.*—Cornaceae are predominantly primitively diffuse porous. Three genera show a slight to pronounced tendency to ring porosity while a fourth is definitely ring porous.

2. *Medullary Ray type.*—The primitive Heterogeneous I type predominates. One genus has the more advanced type Heterogeneous IIA exclusively, while three others have both of these in varying proportions.

3. *Vessel cross-sectional outline.*—The primitive angular outline is characteristic of three genera, the advanced circular outline is characteristic of three, while the balance show intermediate conditions.

4. *Vessel wall.*—Primitive thin, uniform vessel walls occur in approximately half of the genera; the remainder possess comparatively thick, uneven walls and are thus, in respect to this character, relatively advanced.

5. *Vessel Side-wall Pitting.*—The majority of the genera are relatively advanced in respect to this character, possessing chiefly round side-wall pits which are mostly alternately arranged or nearly so. Seven genera have, in addition, some intermediate elongate-elliptic pits. Three genera possess round alternate pits exclusively, and one has the primitive scalariform pit combined with elongate-elliptic.

6. *Vessel Perforation.*—Perforations vary in type from the scalariform with many bars to the advanced simple porous. The highest average number of bars in the nine genera having the scalariform perforation is 52, the lowest 14. Eight genera are exclusively scalariform perforate. One genus possesses simple porous perforations along with few-barred scalariform. Two genera are exclusively porous perforate. To facilitate comparison among the scalariform-perforate genera, an arbitrary point, 31, is taken as a point of division of the scalariform elements into the relatively primitive many-barred and the relatively advanced few-

barred classes. The frequency of occurrence of the few- or many-barred scalariform perforations provides an estimate of the relative position of a genus within the scalariform-perforate group.

7. *Average Vessel Element Diameter.*—The highest generic average for this character is 108 microns, the lowest, 27. Individual vessel elements, especially in the "wide" classes, vary conspicuously in width from one end to the other, frequently being rather distended or swollen in the region of the perforation. All readings for this character were, therefore, taken at the midsection of the entire vessel element, as seen in macerated material.

8. *Average Vessel Element Length.*—Variation in this character is extreme in the family ranging in generic averages from a relatively primitive 2140 microns to a relatively advanced 370 microns. All lengths were read from macerated material, extreme tip to extreme tip (Chalk and Chattaway, 1934).

9. *Ratio of Average Vessel Element Length to Average Vessel Element Diameter.*—The relatively primitive condition is expressed by a high ratio, the relatively advanced by a low. This criterion proposed by Cox (1948) has been found useful in the present instance in interpreting apparent departures from the expected relation of vessel element diameter and length in primitive and advanced classes. For example, in certain genera a comparatively large average diameter is associated with comparatively great average length, and in the genus with the smallest average vessel element length, the average diameter is by no means the greatest for the family. The positive correlation of great vessel element diameter with relative shortness of the element is not invalidated by a specific exception such as that here reported. The general usefulness in evolutionary considerations of the recognized tendency to increasing diameter with advancement in other characteristics requires that the diameter averages be considered, discrepant though they may appear to be, in the evaluation of degree of advancement of the vessel. The length-to-width ratio appears to serve well in this capacity within relatively narrow circles of affinity, and, generally, the ratios so calculated are consonant with the evaluations of evolutionary position obtained by the use of other criteria.

10. *Angle of Vessel end wall.*—Vessel end-wall angle ranges for the family from 8° to 41°, the relatively primitive lying between 8° and 19°, the relatively advanced between 30° and 41°.

11. *Tertiary Thickening of Vessel.*—Two genera show the advanced condition in the possession of spiral tertiary thickening on all vessel walls. One genus has a few vessels thus thickened, while the remaining eight genera are entirely without this feature.

12. *Wood Parenchyma Pitting.*—Pits of wood parenchyma agree in form, disposition and occurrence with the side-wall pits of vessels.

13. *Fibrous elements.*—One genus possesses the primitive fiber-tracheids exclusively; one has only the advanced libriform wood fiber, while the remaining nine genera have combinations of the two types of fibrous elements in various proportions.

14. *Fiber Septation.*—Septate fibers are a mark of comparative advancement.

One genus, that with libriform wood fibers exclusively, has almost all of these elements septate. Two other genera possess both septate and non-septate fibers, the latter in higher proportion. The remainder are wholly without septate fibrous elements.

DISCUSSION

The relatively conservative treatment of Cornaceae by Wangerin (1910) provides a broad base upon which the data derived from wood anatomy may be superimposed.

Detailed information on the anatomy of the wood of Cornaceae is largely lacking. Solereder (1908) and Hoar (1915) note the diffuse arrangement of narrow, scalariform perforate vessels, sparse and diffuse wood parenchyma as general characters of the family. Exceptions such as the simple perforations and wide vessel lumina in the specialized genera *Torricellia*, and *Kaliphora* are recorded. Wilkinson (1944) has carefully studied the vascular anatomy of the flower of certain species of *Cornus*. Other genera of the family have been similarly treated by Horne (1914).

The family Cornaceae is composed of trees and shrubs or rarely small perennial herbs with opposite or alternate, simple, exstipulate (except *Helwingia*) leaves. Flowers are small, actinomorphic, hermaphrodite or dioecious, in racemes or open panicles, ample or much reduced cymes simulating umbels or capitules. Calyx 4-5 lobed; petals 4–5, rarely 7 or 8 or absent, valvate or imbricate; stamens 4–5, alternate with petals; cushion-like epigynous disc in pistillate and perfect flowers; ovary inferior, 1–4-locular; ovules solitary in each locule, with one integument. Fruit a 1–4-celled berry or drupe. Wood mostly diffuse porous; vessels many-barred scalariform perforate or rarely simple porous perforate; wood parenchyma sparse and diffuse; rays heterogeneous.

Subfamily MASTIXIOIDEAE Harms

Small trees with opposite or alternate coriaceous leaves. Flowers hermaphrodite, small, in many-flowered terminal, dichotomous, bracteate panicles, or cymes. Calyx 4- or 5-toothed; petals 4 or 5; stamens 4 or 5, alternate with petals; ovary 1-locular, with solitary ovule and angled epigynous disc. Wood diffuse porous. Vessel elements angular in outline, the walls moderately and unevenly thickened. Perforation scalariform, many-barred. Vessel side-wall pits mostly elongate-elliptic to round. Fibrous elements chiefly fiber-tracheids, non-septate. Rays Heterogeneous I.

The genus *Mastixia* Blume, constituting the subfamily, consists of about 20 species which are grouped into two subgenera by Wangerin, *viz: Tetramastixia* and *Pentamastixia* on the basis of the number of floral parts. Danser (1935) questions the value of this character as a basis for separating subgenera. The genus occurs from western India and Ceylon throughout the East Indies to the Philippines and the Solomon Islands.

On much of the anatomical evidence *Mastixia* appears to be relatively primitive. It possesses the greatest average number of bars in the vessel perforations,

52, and the highest proportion of many-barred (over 30) plates, 100%, to be found in the entire family. The end-wall angle is the lowest for the family, 8°, and the vessel elements average longest, 2140μ. Side-wall pitting, although chiefly round and elongate-elliptic, is frequently scalariform. The primitive aspect is further suggested by the Heterogeneous I rays, striking angularity of vessel outline and predominance of fiber-tracheids over libriform elements. Advanced features are not wanting, however. Most importantly, the average vessel diameter, 108μ, is the largest for Cornaceae. Ratio of average vessel element length to width is nearly 20:1.

Notable among the advanced morphological features of *Mastixia* is the unilocular ovary, a feature deserving considerable weight in estimating the phylogenetic position of the genus. The occurrence of 4- or 5-merous flowers about equally in the genus suggests a relatively recent and perhaps progressing derivation. The multiflorous open panicle is a mark of primitiveness within the family.

Mastixia would appear to have evolved more rapidly in floral structure than in anatomical features. The exceptionally great average vessel diameter is the chief anatomical feature to indicate an advance comparable to that of the flower. The average of vessel element length-width ratios, 20:1, when treated comparatively with that of other genera places *Mastixia* in a relatively primitive position in Cornaceae.

The variation of vessel characteristics among certain of the species of *Mastixia* examined are set forth in the following table.

M. trichotoma Blume (Y #31020—*Janssonius 3100a*); *M. rostrata* Blume (Y #31022—*Janssonius 2309a*); *M. caudatifolia* Merr. (Y #20240—*Foster*), *M. tetrandra* (Wight) Clarke (US—*Thwaites 2441*, isotype), *M. Korthalsiana* Wang (Y #15458—*Van de Koppel 4085*); *M. philippinensis* Wang. (Y #34219), *M. pentandra* Blume (US—*Kajewski 2086*).

	M. trichotoma	*M rostrata*	*M caudatifolia*	*M. Korthalsiana*	*M philippinensis*
Vessel length					
Max. .	2128μ	2397μ	2652μ	3144μ	3668μ
Min.	1375μ	1408μ	1689μ	1932μ	1735μ
Aver.	1677μ	1763μ	2146μ	2422μ	2414μ
Vessel diam.					
Max	145μ	131μ	100μ	155μ	134μ
Min	77μ	93μ	65μ	99μ	90μ
Aver.	105μ	115μ	81μ	120μ	110μ
Ratio	16:1	15:1	26:1	20:1	21:1
Perforation					
% scal. 31 + bars	100	100	100	100	100
% scal. 30 − bars	0	0	0	0	0
Av no bars	48	44	51	48	66

Omitted from the above table are *M. pentandra* and *M. tetrandra* for which only very youthful material was available. It is interesting to note, however, that whereas the vessel dimensions are considerably lower the vessel element length-to-width ratio is consistent with those cited above, being 23:1 for the former and 17:1 for the latter. With the exception of the very high ratio for *M. caudatifolia* which is tetramerous, the generally higher ratios of the pentamerous

species suggests a more primitive standing for this group. This is, of course, a reflection of the significantly greater average length of the vessel elements in the latter group. Similarly, the average number of bars per perforation plate tends to be higher in the pentamerous species examined. However, it is questionable whether such correlations would hold in an extended series of observations, in view of Danser's inability to find correlative differences between many of the tetramerous and péntamerous species, and his occasional finding of both floral conditions in the same species.

Subfamily CURTISIOIDEAE Harms

Trees with opposite coriaceous leaves. Flowers hermaphrodite, minute, in many-flowered terminal dichotomous, bracteate panicles. Calyx 4-lobed; petals 4; stamens 4, alternate with petals; ovary 4-locular, with solitary ovule in each cell and angled epigynous disc. Wood diffuse porous. Vessel elements circular in outline, the walls moderately and unevenly thickened. Perforation scalariform, mostly few-barred. Vessel side-wall pits mostly round. Fibrous elements chiefly fiber-tracheids, non-septate. Rays of type Heterogeneous I.

The genus *Curtisia* Ait., constituting the subfamily Curtisioideae is represented by a single species, *C. faginea* Ait., endemic to South Africa.

Curtisia seems, on anatomical evidence, to occupy an equivocal position within the family. The average vessel element length is the second greatest in Cornaceae, while the average vessel element diameter is almost exactly the average for the family. Vessel element length-to-width ratio is 19:1. In other respects the vessel elements are more derived. Thus, the perforation plates average 26 bars, although 30% of the plates have 31 or more bars. Similarly the end-wall angle averages 24° which is above the 19° average for the family. Side-wall pitting is predominantly round with a few elements bearing some pits of the more primitive elongate-elliptic type. The fibrous elements are chiefly the more primitive fiber-tracheids. In flower structure also, a combination of relatively primitive and advanced characters occurs, namely the 4-locular ovary and tetramery.

Evaluation of such conflicting evidence is difficult, but it does appear that the primitive features carry a somewhat greater weight, and a relatively primitive position is thus assigned to the subfamily. *Curtisia* serves well to illustrate the unevenness of evolutionary rate among the complex of characters both anatomical and morphological.

The variation of vessel characteristics in *Curtisia faginea* are shown in following table.

C. faginea Ait. (Y #14934—Forestry Dept., Pretoria. #Ind. 807; NY—ex Herb. Kew; US—*Swynnerton 637*).

Vessel length	
Max.	1539μ
Min.	851μ
Av.	1207μ
Vessel diam.	
Max.	120μ

Min.	32μ
Av.	63μ
Ratio	19:1
Perforation	
% Scal. 31 + bars	30
% Scal. 30 − bars	70
Av. no bars	26

Subfamily CORNOIDEAE Harms

Trees, shrubs or rarely perennial herbs with opposite or alternate, mostly exstipulate leaves. Flowers hermaphrodite or dioecious, small, in racemes, panicles, umbels, or capitate clusters. Calyx 4–5 (rarely 7) lobes, adnate to ovary; petals 4–5 (rarely 3 or 7) or absent, valvate or imbricate; stamens 4–7, alternate with petals; ovary 1–4-locular with ovules solitary in locules, central or epigynous disc angled or rounded, prominently fleshy or obscure. Wood diffuse porous, rarely ring porous. Vessel elements angular to round in outline, the walls thin and even to thick and uneven. Perforation many- or few-barred scalariform or simple porous. Vessel side-wall pits elongate-elliptic to round (rarely scalariform). Fibrous elements fiber-tracheids to libriform fibers, rarely septate. Rays Heterogeneous I or rarely IIA.

The subfamily exhibits a wide range of morphological and anatomical variation. Some of the most primitive features and the most advanced shown by the family are found among the nine genera of this subfamily. Wangerin recognizes four tribes, *viz:* Torricellieae, Helwingieae, Griselinieae, and Corneae. In the light of the present study, it has seemed desirable to propose two new tribes, *viz:* Aucubeae consisting of the genus *Aucuba*, and Kaliphoreae consisting of the genus *Kaliphora*, both included in Corneae of Wangerin.

Tribe CORNEAE Wangerin

Trees or shrubs, very rarely perennial herbs, with opposite, rarely alternate, leaves. Flowers hermaphrodite or very rarely dioecious, with 4 or 5 (rarely 6–8) petals and stamens; on non-articulate pedicels, singly on short branches, or in loose or compact cymes, panicles, or small heads. Ovary 1- to 4-locular. Fruit a 1- to 4-seeded drupe. Wood diffuse porous. Vessel elements angular to angular-rounded with thin even walls and elongate-elliptic to round side-wall pits. Perforations scalariform, many- or few-barred. Rays Heterogenous I and rarely transitional to Heterogeneous IIA.

The tribe Corneae as here considered includes *Cornus* L., *Corokia* A. Cunningh., and *Lautea* F. Brown.

Lautea with two species is endemic to the island of Rapa in the South Pacific. Calyx lobes, petals and stamens vary in number from 5 to 8. The ovary is 2- to 4-locular. Anatomically the genus appears relatively primitive with a vessel length-width ratio of 21:1 and sharply angular vessel outline. Brown (1928) reports the presence of tertiary spiral thickening on vessel walls which is not confirmed by the present study. The fibrous elements, predominantly fiber-tracheids, are non-septate although Brown reports septa present. In the vessel perforations, however, the genus occupies a comparatively advanced position. The scalariform perforations are exclusively of the few-barred type, the average

number of bars being 20. Vessel side-wall pitting is predominantly round, but a conspicuous proportion of the vessels have the more primitive elongate-elliptic type. End-wall angle is low, 13°.

Brown is correct in assigning a primitive position within the tribe to *Lautea*. This he does on the basis of the high and variable number of flower parts, including the multilocular ovary, as well as anatomical data among which he emphasizes the extreme narrowness of vessel segments (reporting 31μ average).

Variations in vessel characteristics are shown in the following table.

Lautea collenettii (Riley) F. Brown, (Y #37337—*St. John 3696*); *L. stokesiana* F. Brown, (Y #24281—*Stokes 433*). These are the same species; the former is the valid name.

Vessel length	
Max.	1015μ
Min.	687μ
Av.	798μ
Vessel diam.	
Max.	54μ
Min.	26μ
Av.	38μ
Ratio	21:1
Perforation	
% Scal. 31 + bars	0
% Scal. 30 − bars	100
Av. no. bars	20

Corokia with three species in New Zealand and Chatham Is. is closely related to *Lautea* from which it differs chiefly in having the flower parts stabilized in 5's, with a 1- or occasionally 2-locular ovary. The closeness of relationship is reflected also in anatomical features. Thus vessel element measurements and structural features such as angular cross-sectional outline, thin even walls, angle of end wall (13°), and perforation as well as ray type are in close agreement with those of *Lautea*. The vessel length-width ratio for *Corokia* is 24:1, a relatively more primitive condition. The average vessel diameter here reported is about twice the figure cited for *Corokia* by Solereder. It appears probable that his figure (13μ) was taken from extremely youthful material of *C. buddleioides*. Fibrous elements appear to be exclusively fiber-tracheids and are non-septate.

From the facts of floral morphology and distribution, Brown (1928) concludes, with special emphasis upon the reduced ovary (cf. Mueller, 1864; Wangerin, 1910), that *Corokia* is a possible derivative of *Lautea*. With this view, the anatomical evidence seems not greatly inconsistent.

Variations in anatomical characters are shown in the following table.

Corokia cotoneaster Raoul (US—*Cheeseman*); *C. buddleioides* A. Cunningh. (US—Wilkes Exped.)

	C. cotoneaster	*C. buddleioides*
Vessel length.		
Max.	884μ	812μ
Min.	399μ	524μ
Av.	641μ	641μ

Vessel diam.		
Max.	26μ	38μ
Min.	20μ	24μ
Av.	23μ	31μ
Ratio	27:1	21:1
Perforation		
% Scal. 31 + bars	0	0
% Scal. 30 − bars	100	100
Av. no. bars	18	23

Cornus, with about 50 species, is the most widely spread member of the family; it occurs throughout the north temperate regions and two species are montane tropical in South America and Africa.

Trees, shrubs or rarely perennial herbs with opposite or rarely alternate leaves and small, hermaphrodite or rarely dioecious flowers in open, usually ebracteate, or much condensed, often involucrate cymes resembling umbels or capitules. Petals and stamens, 4; ovary 2-locular; drupe sometimes 1-seeded.

Wangerin's treatment of *Cornus* recognizes seven subgenera, two sections and four subsections. Twenty-seven species, some represented by several specimens were available for study. For the North American species the treatment of Rickett (1945) is followed as to synonymy.

Variation in anatomical detail is considerable, as may be expected, in this large genus. The tables following show such variations among representative species in each subgenus.

Subgen. *Thelycrania: C. alternifolia* L. (Y #40158—*Hicock;* auth. collection); *C. controversa* Hemsl. (Y #14602—Inst. Wood Tech., Tokyo); *C. parviflora* Chien (Y #21905—*Y. Tang); C. occidentalis* Cov. (Y #26954—*Quick;* Y. #11525, as *C. pubescens* Nutt.—U. S. For. Serv.); *C. stricta* Lam. (Y #11888—U. S. For. Serv.; CNC #11250; Y #11912, as *C. obliqua* Raf.—*Kribs*); C. *stolonifera* Michx. (Y #14863—*Detwiler 138;* CNC #15969); *C. asperifolia* Michx. (Y #40652—*Opdyke;* CNC #11857; #3867; *Brush 10220*); *C. rugosa* Lam. (Y #27189, as *C. circinata* L'Her.—U. of Mich. Biol. Sta.; CNC #8476); *C. racemosa* Lam. (Y #39338, as *C. candidissima* Mill.—*Hickock;* CNC #3898, as *C. candidissima* Marsh.; #14284, as *C, paniculata* L'Her.; #1854; #9722, as *C. paniculata* L'Her.); *C. peruviana* Macbr. (Y #31992 —*Rimback*); X *C. californica* Mey. (Y #27285—*Webber*); *C. macrophylla* Wall. (Y #40801—cultiv., *Graves*); *C. Walterii* Wang. (Y #23066—Fan. Mem. Inst. Biol #13); *C. sanguinea* L. (Y #40800—cultiv., *Graves*); *C. amomum* Mill, (Y #24416—*Marco 24;* CNC #11069; auth. collection.

Subgen. *Macrocarpium: C. chinensis* Wang. (Y # 21808—*Y. Tang*); *C. officinalis* Sieb. & Zucc. (Y #32297—*Yamabayashi*); *C. mas* L. (Y #12679—cultiv., *Mulliner*; cultiv., auth. collection).

Subgen. *Afrocrania: C. volkensii* Harms (Y #27557—*Schieben 3884*).

Subgen. *Discocrania: C. disciflora* Moc. & Sesse (Y #38408—*Stork 4194*).

Subgen. *Arctocrania: C. canadensis* L. (CNC—*Mathews 282;* #12955—*Coker*).

Subgen. *Benthamidia: C. florida* L. (Y #40248—*Hess 157;* auth. collection); *C. nuttallii* Audub. (Y #19917—Field Mus. #73428; CNC—*Crum 2110*).

Subgen. *Benthamia: C. hongkongensis* Hemsl. (Y #21971—*Y. Tang*); *C. kousa* Buerg.(Y #29346—cultiv., Arn. Arboret. #13122-B); *C. capitata* Wall. (Y #21912—*Y. Tang.*)

	C. alternifolia	*C. controversa*	*C. brachypoda*	*C. parviflora*	*C. occidentalis*
Vessel length					
Max.	1310μ	1441μ	1441μ	1951μ	1427μ
Min.	707μ	877μ	982μ	1506μ	491μ
Av.	813μ	1113μ	1225μ	1727μ	915μ
Vessel diam.					
Max.	63μ	124μ	133μ	69μ	116μ
Min.	31μ	77μ	86μ	46μ	31μ
Av.	45μ	97μ	69μ	60μ	74μ
Ratio	18:1	11.4:1	17.7:1	28:1	12.6:1
Perforation					
% Scal. 31 + bars	100	100	0	100	0
% Scal. 30 − bars	0	0	100	0	100
Av. no. bars	43	34	24	62	28

	C. stricta	*C. stolonifera*	*C. asperifolia*	*C. rugosa*	*C. racemosa*
Vessel length					
Max.	1146μ	989μ	1251μ	995μ	1179μ
Min.	497μ	524μ	668μ	609μ	815μ
Av.	776μ	796μ	966μ	801μ	857μ
Vessel diam.					
Max.	82μ	77μ	89μ	79μ	62μ
Min.	40μ	31μ	31μ	43μ	38μ
Av.	53μ	45μ	49μ	59μ	49μ
Ratio	14.7:1	18.8:1	21:1	13.5:1	17:1
Perforation					
% Scal. 31 + bars	50	54	53	58	0
% Scal. 30 − bars	50	46	47	42	100
Av. no. bars	32	31	37	30	25

	C. peruviana	X *C. californica*	*C. macrophylla*	*C. Walterii*	*C. sanguinea*
Vessel length					
Max.	1617μ	1087μ	884μ	1310μ	1080μ
Min.	982μ	622μ	589μ	720μ	524μ
Av.	1382μ	812μ	745μ	953μ	743μ
Vessel diam.					
Max.	102μ	68μ	77μ	116μ	77μ
Min.	57μ	35μ	38μ	77μ	37μ
Av.	79μ	56μ	53μ	97μ	57μ
Ratio	17.5:1	14.5:1	13.9:1	9.8:1	12.8:1
Perforation.					
% Scal. 31 + bars	28	0	0	0	0
% Scal. 30 − bars	72	100	100	100	100
Av. no. bars	27	26	21	19	22

	C. amomum	*C. chinensis*	*C. officinalis*	*C. mas*	*C. volkensii*
Vessel length					
Max.	1192μ	1689μ	1362μ	1637μ	1820μ
Min.	569μ	849μ	753μ	641μ	1061μ
Av.	825μ	1316μ	1040μ	911μ	1451μ
Vessel diam.					
Max.	65μ	79μ	62μ	93μ	134μ

Min	38μ	51μ	32μ	31μ	55μ
Av	52μ	68μ	47μ	52μ	93μ
Ratio	15 8:1	19 3:1	22:1	18:1	15.6:1
Perforation					
% Scal. 31 + bars	50	100	46	12	100
% Scal 30 − bars	50	0	54	88	0
Av no bars	30	47	31	27	44

	C disciflora	C canadensis	C. florida	C. nuttallii
Vessel length				
Max	1748μ	602μ	1244μ	1414μ
Min	799μ	209μ	825μ	1113μ
Av	1310μ	370μ	1030μ	1195μ
Vessel diam				
Max	155μ	37μ	85μ	116μ
Min	88μ	23μ	57μ	83μ
Av	119μ	31μ	78μ	97μ
Ratio	11.1	12.1	13.2 1	12.3:1
Perforation				
% Scal 31 + bars	75	0	94	63
% Scal. 30 − bars	25	100	6	37
Av no. bars	31	17	41	31

	C hongkongensis	C kousa	C capitata
Vessel length			
Max	1951μ	1519μ	1578μ
Min	1270μ	858μ	694μ
Av	1578μ	1231μ	1028μ
Vessel diam			
Max	96μ	77μ	93μ
Min	60μ	46μ	54μ
Av	80μ	55μ	74μ
Ratio	19 8:1	22 1:1	13 9 1
Perforation			
% Scal 31 + bars	90	100	100
% Scal 30 − bars	10	0	0
Av no bars	48	49	47

The subgenera of *Cornus* may be arranged in two series on the basis of inflorescence. One of these, consisting of the subgenera *Thelycrania*, *Afrocrania*, and *Arctocrania*, is characterized by an ample and open, or small and more or less congested, obviously cymose inflorescence. The other, consisting of *Macrocarpium*, *Benthamia*, *Benthamidia*, and *Discocrania*, is characterized by inflorescence which has attained forms simulating very closely umbels and capitules (Rickett, 1944). The series here described are not necessarily regarded as groups of especially closely related subgenera, but as convenient expressions of degree of reduction of inflorescence. However, a linear arrangement of the subgenera in order of progressing reduction does not, in view of anatomical data, express adequately the relationships among the subgenera.

The subgenus *Thelycrania* embracing a majority of the species of *Cornus* is represented in the present study by sixteen out of a total of thirty-two species. Included in this list are representatives of all sections and subsections (except subsect. Oblongifoliae, with one species) according to the treatment of Wangerin.

On character of inflorescence, *Thelycrania* is clearly the most primitive subgenus. When compared anatomically with all the remaining subgenera (which display a greater or less reduction of inflorescence) taken as a group, its relative primitiveness is less clearly marked but plainly suggested.

	Av. no. bars	*Av. ves. length*	*Av. ves. diam.*	*Av. ves. L-W ratio*	*Av. fiber length*
Thelycrania	36	1000	65	16.5:1	1669
Other subgen.	35	1087	74	15.8:1	1321

Individual comparison of *Thelycrania* with the other subgenera, however, reveals that it is preceded in primitiveness of anatomical expression by two other subgenera, *viz.*, *Macrocarpium* and *Benthamia*. This is somewhat surprising in view of the significantly advanced morphological characters of these subgenera, the former possessing an "umbellate" type of inflorescence and the latter a "capitate" with petaloid involucre and syncarpous fruit.

The subgenus *Macrocarpium* is anatomically the most primitive. Average number of bars per perforation is 35, equal to the average for *Cornus;* 53% of the perforations have more than 31 bars. Vessel element length is about equal to the average for the genus, but the diameter is considerably lower, giving a vessel length-width ratio of nearly 20:1, highest for *Cornus*. Fibrous elements, predominantly fiber-tracheids, are among the longest in the genus, exceeding the average for the genus by about 200μ. Wood parenchyma, although predominantly diffuse, occurs sparingly in thin metatracheal bands. Although anatomically more primitive than *Thelycrania*, *Macrocarpium* could not represent the direct source of that subgenus or others which possess a more primitive inflorescence pattern. However, it is both anatomically and morphologically primitive with respect to the other three subgenera in the "umbellate-capitate" series and may be conceived as a probable source of them. The tendency to petaloidy of the involucral bracts exhibited by one species, suggests *Macrocarpium* as an equally likely source of conspicuous petaloidy where it occurs in the "capitate" subgenera.

The subgenus *Benthamidia* with two American species represents an advancement over *Macrocarpium* in both anatomical and morphological features. Although average vessel element length, 1112μ, is slightly greater than the average for the genus, average vessel width, 87μ, is considerably greater, giving a length-width ratio of about 13:1. The average number of bars per scalariform perforation plate, 36, is about equal to the average for the genus, although about 78% of the plates show more than 31 bars. Fibrous elements are about equally fiber-tracheids and libriform elements whose length is somewhat less than the genus average. The small "capitate" terminal inflorescence of sessile flowers is clearly derivative from the "umbellate" type of *Macrocarpium*. The conspicuous petaloid involucre, a mark of specialization in *Cornus*, appears to have arisen rather independently in various subgeneric groups. In the present instance it may well have developed from one similar to the subpetaloid involucre of *C. sessilis*.

Anatomically the subgenus *Benthamia* with three Asiatic species is little advanced over *Macrocarpium* from which it may have been derived independently of the other petaloid-bracteate subgenus, *Benthamidia*. Its relatively primitive

position is shown by vessel elements which are some 200μ longer than average for the genus and considerably narrower, 69μ, giving a high length-width ratio of almost 19:1. Average number of bars per perforation plate is 48, highest for the genus, with about 97% of the plates having in excess of 31 bars. One species, *C. capitata* Wall., with exceptionally short vessel segments has a length-width ratio of 14, but otherwise is in agreement. Fibrous elements which are almost wholly fiber-tracheids average about 200μ longer than the average for the genus. *C. kousa* displays a few small metatracheal bands of wood parenchyma. The conspicuously petaloid-bracteate and "capitate" inflorescence of this subgenus appears to ally it closely with *Benthamidia* over which it shows a marked advance in the fusion of its drupes at maturity into a fleshy syncarpium. However, in view of the strongly primitive anatomical condition of *Benthamia*, it appears reasonable to assume its derivation rather more directly from *Macrocarpium* by the development of a condensed "capitate" inflorescence and of a petaloid involucre quite independently from *Benthamidia*, and possibly earlier. The modified condition of the fruits, then, is an advanced feature not attained by the anatomically more highly specialized *Benthamidia*.

Discocrania, a subgenus with one or two species, presents a mixed picture. Anatomically it is highly specialized in some features and rather primitive in others. Average vessel element length is 1310μ, considerably above the average for the genus, but the length-width ratio is very low (11:1) by virtue of the great average width, 119μ, of the vessel elements. Bars of the perforation plates average 31 in number, but 75% of the plates possess in excess of 31 bars. Fibrous elements, which are chiefly fiber-tracheids with some libriform fibers, are somewhat longer than the average. Medullary ray type is unique for this series, being of type Heterogeneous II B. The condensed, "capitate" inflorescence is a morphological advance associating *Discocrania* with *Benthamidia* and *Benthamia*, but the involucre consists of small herbaceous, promptly deciduous bracts, which suggests affinity more directly with *Macrocarpium*. The advanced type of medullary ray and low vessel length-width ratio appear to require the placement of *Discocrania* as the most advanced of the capitate subgenera notwithstanding its relatively primitive involucre. It appears reasonable to suppose, therefore, that it may have originated at a point along the line from *Macrocarpium* to *Benthamidia*, probably rather close to the former.

The subgenus *Afrocrania* with one species in the eastern African highlands is the only representative of the genus on that continent. Vessel elements are considerably longer, 1451μ, than the average for the genus but are, second to *Discocrania*, the widest, 93μ, thus giving a relatively low vessel length-width ratio of 15.6:1. The number of bars per perforation plate is unexpectedly high, averaging 44. Angle of the end wall to side wall is high, 22°. Vessel outline is decidedly round and the walls conspicuously and unevenly thickened. In arrangement, the vessels tend to occur in small multiples, although the usual solitary arrangement predominates. Fibrous elements which are only slightly longer than the genus average are predominantly libriform, while the pits of the fiber-tracheids are much reduced. Morphological features of a derived character are the dioecism

of the flowers and the comparative congestion of the inflorescence. However, the inflorescence does not attain the degree of reduction shown by the essentially umbellate inflorescence of *Macrocarpium*, but clearly resembles the more primitive open cymes of *Thelycrania*, except that the latter is ebracteate. The bracts of the inflorescence are herbaceous and promptly deciduous. These relatively primitive morphological features suggest an origin relatively close to, but below, *Macrocarpium* while the dioecism, congestion of the cyme, and advanced anatomical features suggest an attained evolutionary position well above that group.

The subgenus *Arctocrania* with two boreal circumpolar species is unique in the genus in possessing an herbaceous stem and a commonly unilocular 1-seeded fruit. Anatomical data suggest a high degree of specialization. Vessel elements are the shortest in the genus, 370μ, and although they are also the narrowest, the length-width ratio is, next to *Discocrania*, the lowest. Number of bars per perforation plate is lowest for the genus, 17. The inflorescence is a much reduced cyme subtended by petaloid bracts, but it does not approach, in reduction, the typical umbellate form of *Macrocarpium*, although exceeding that of *Afrocrania*. To the extent that the inflorescence of *Arctocrania* thus shows a more primitive condition than that of *Macrocarpium*, its origin might be considered to be below but close to that subgenus. Derivation from *Benthamidia* is unlikely since the inflorescence of *Arctocrania* is of a more primitive type. Its evolutionary specialization has culminated in the herbaceous habit, the attainment independently of a petaloid involucre, and a high degree of anatomical specialization.

A graphic presentation of the probable interrelationship of the subgeneric groups is set forth in figure 1. The occurrence within the genus *Cornus* of a number of essentially independent evolutionary trends in morphological characters has resulted in the recognition of several definable units consisting of groups of species. These groups of species have variously been accorded generic, subgeneric, and sectional rank by authors. Whatever the taxonomic rank accorded such species groups, it appears that the phylogenetic development of the genus has not been a straight-line, step-by-step process throughout, but essentially a fanning out of derived groups of species from some less specialized form. Such a hypothetical ancestor probably did not resemble closely any of the modern species, but contained potentialities for the subsequent derivation of all of them. Judged upon morphological grounds, the large subgenus *Thelycrania*, including the alternate-leaved *C. controversa* and *C. alternifolia*, should be assigned a most primitive position. Its inflorescence, usually an ample, ebracteate cyme, is clearly primitive. Such a cyme may be subject to consolidation or reduction, resulting in such degrees of congestion and reduction of inflorescence as characterize the subgenera *Afrocrania* and *Arctocrania*, or through further reduction to give the "umbellate" inflorescence of *Macrocarpium* and, ultimately, the "capitate" type of *Benthamia*, *Benthamidia*, and *Discocrania*. From the anatomical picture, however, it must be clear that the subgenera could not have arisen in a straight line as the progressive reduction of inflorescence suggests. This view seems to be supported also by the fact that, although the reduced types of inflorescence are

involucrate, the involucres behave variously and assume forms that are not in general directly related to degree of inflorescence reduction. Nor does involucral type bear a constant relation to degree of anatomical specialization.

Therefore, *Macrocarpium* which is anatomically less specialized but morphologically more advanced than *Thelycrania* may be the oldest of the modern species groups which resulted from a very rapid reduction of inflorescence from a loosely cymose type to "umbellate", while retaining its primitive anatomical characters. The modern *Thelycrania* represents a parallel offshoot from a primitive stock, whose chief evolutionary progress has been marked by comparatively great

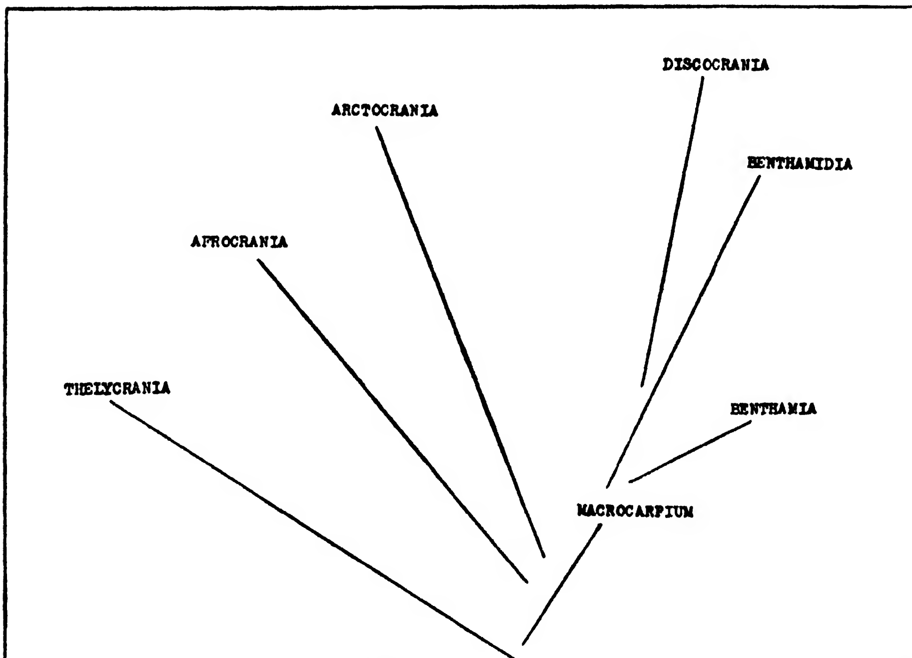


FIG. 1. Phylogenetic relationships among subgenera of *Cornus*

anatomical advance but little morphological change. The low order of anatomical specialization of *Benthamia*, coupled with its highly derived, "capitate" and petaloid-involucrate inflorescence and syncarpous fruit, place it as an early derivative of *Macrocarpium*, which in development of the syncarpous fruit has assumed a unique position within the genus. *Benthamidia*, in which the inflorescence is also "capitate" and petaloid-involucrate, but whose drupes are free, could not have been derived from the anatomically more primitive *Benthamia*, but must have had its source in *Macrocarpium*. *Discocrania*, with a "capitate" and herbaceous-involucrate inflorescence, is anatomically the most specialized. Its origin may be thought to have been a point along the line from *Macrocarpium* to *Benthamidia* subsequent to the reduction of inflorescence to the "capitate" condition. *Afrocrania* and *Arctocrania*, with reduced and involucrate inflores-

cence, the latter with petaloid bracts, originated at a time subsequent to the divergence of *Macrocarpium* and *Thelycrania* from the parent stock, but prior to reduction of the primitive inflorescence to the "umbellate" form.

Of interest in this connection are the results of investigations of chromosome numbers in the genus, by Dermen (1932) and others. From observations of species representing five of the subgenera, Dermen concludes that those with the lowest chromosome number (n = 9) are primitive. By segmentation and duplication higher numbers (n = 10, n = 11, n = 22) are obtained. On this evidence, *Macrocarpium* (*C. mas*, *C. officinalis:* n = 9) is primitive, *Thelycrania* (*C. alternifolia*, *C. controversa:* n = 10; *C. amomum*, *C. rugosa*, etc.: n = 11) is derived, *Benthamia* (*C. capitata*, *C. kousa:* n = 11) and *Benthamidia* (*C. florida*, *C. nuttallii:* n = 11) are derived. Dermen suggests the derivation of *C. canadensis* (n = 22) of the subgenus *Arctocrania* from a form like *C. florida* by duplication. However, in *C. suecica* of *Arctocrania* n = 11 (Darlington and Janaki Ammal, 1945). It seems not unreasonable to conceive of a primitive "pro-*Cornus*" stock, *Thelycrania*-like in inflorescence, in which n = 9.

Tribe AUCUBEAE Trib. nov.

Small evergreen trees or shrubs with opposite, shining coriaceous leaves. Flowers tetramerous, dioecious, on 2-bracteolate, articulate pedicels in axillary or terminal dichotomous panicles. Ovary 1-celled, with 1 ovule. Fruit a scarlet berry. Wood diffuse porous and tending to semi-ring porous. Vessel elements angular to slightly rounded with thin, even walls, spiral tertiary thickening and elongate-elliptic to round side-wall pitting. Perforations scalariform, mostly many-barred. Rays Heterogenous I and Heterogenous IIA.

This tribe consists of the single genus *Aucuba* Thunb. with three closely related species of Japan, China and the eastern Himalayas. Wangerin includes *Aucuba* in the Tribe Corneae. In morphological and anatomical characters, *Aucuba* presents a picture which seems best viewed as the culmination of a line of evolution apart from *Cornus*, *Corokia*, and *Lautea*. Its coriaceous leaves, long-persistent epidermis and green stems give it a distinctive aspect, although the stems of some *Cornus* species retain the epidermis and remain green for a few years, and *Corokia* and *Kaliphora* have evergreen coriaceous leaves. Articulated pedicels are found elsewhere in the subfamily only in Torricellieae and Griselinieae, the latter also sharing the baccate fruit. The tetramerous, dioecious flowers and 1-locular ovary are indicative of considerable morphological advancement. Anatomically, *Aucuba* displays a mixture of primitive and derived characters and conditions. In number of bars per perforation plate it stands in the second most primitive position within the family, with an average of 45, with about 74% of the plates having more than 31 bars. Vessel element end walls incline to the long axis at an average angle of 12°. Vessel elements average 972μ, but this moderate length is associated with very small average diameter, 37μ, giving a vessel length-width ratio averaging slightly more than 26:1. Vessel outline in cross section is predominantly angular, with the walls thin and even. Fibrous elements are about equally fiber-tracheids and libriform fibers. Coupled with these relatively primitive features are derived ones which indicate a striking unevenness in

evolutionary rate. Thus, the wood exhibits a definite tendency to a semi-ring porous condition in one species, while the rays are mostly Heterogeneous IIA with some of the less specialized Heterogeneous I. Vessel side walls are predominantly round pitted, and conspicuously marked with tertiary spiral thickenings. Some fibrous elements also show tertiary spirals. Tertiary thickening is found elsewhere in the family in *Torricellia* and to a limited extent in *Helwingia*. Solereder (1908) reports tertiary thickening in *Cornus oblonga* Wall., which was not available for the present study.

The extent of variation in anatomical characters among the species is shown in the following table.

Aucuba chinensis Benth. (Y #21794—Fan Mem Inst. #0182, NY—*C. Wang 36513*); *A. japonica* Thunb. (Y #14600—*M. Fujioka*, cultiv., auth. collection); *A. himalaica* Hook f et Thoms. (NY—*J. D. Hooker*)

	A chinensis	*A japonica*	*A himalaica*
Vessel length			
Max.	1290μ	1192μ	1074μ
Min.	812μ	622μ	720μ
Av.	1085μ	952μ	878μ
Vessel diam			
Max	59μ	49μ	37μ
Min	28μ	31μ	28μ
Av.	39μ	39μ	35μ
Ratio	28.1	25·1	25:1
Perforation			
% Scal. 31 + bars	50	100	100
% Scal. 30 − bars	50	0	0
Av no. bars	35	56	45

Tribe KALIPHOREAE Trib. nov.

Trees or shrubs with alternate coriaceous leaves. Flowers tetramerous, dioecious, on ebracteate, non-articulate pedicels in small axillary panicles. Ovary 2-celled, a single ovule in each cell. Fruit drupaceous, separable into two 1-seeded nutlets. Wood diffuse porous, tending to semi-ring porous. Vessel elements round in outline, unevenly thick walled, with much reduced, round pits on side walls. Perforations simple porous, the end walls oblique. Rays of type Heterogeneous II A.

Kaliphoreae consists of the monotypic genus *Kaliphora* Hook. f. of Madagascar. Included in Corneae by Wangerin, its removal therefrom is based chiefly upon anatomical characters. Among the Corneae of Wangerin its separable fruit is distinctive as are the elongate, elliptic, basifixed anthers. Anatomically the genus occupies a very advanced position. In the semi-ring porous wood the vessels occur frequently in short radial chains and singly. Vessels are very short, averaging 370μ, comparatively wide, 49μ, giving a length-width ratio of 7.5:1, second lowest for the family. The simple porous vessel element end wall is inclined to the long axis of the vessel at an average angle of 41°, highest for the family. Fibrous elements are almost entirely libriform. The Heterogeneous IIA rays are a mark of advancement found elsewhere in the family as the sole type only in *Torricellia*. The tribe appears to represent the result of an extensive anatomical and morpho-

logical specialization whose point of departure is difficult to locate with reference to other genera of the Corneae of Wangerin, but it appears to be more closely related to *Corokia* than to *Cornus*.

Variation in anatomical characters is shown in the following table.

Kaliphora madagascariensis Hook. f. (P #899—*R. Baron* in 1889).

	K. madagascariensis
Vessel length	
Max.	471μ
Min.	248μ
Av.	370μ
Vessel diam.	
Max.	69μ
Min.	34μ
Av.	49μ
Ratio	7.5:1
Perforation	Porous

Tribe HELWINGIEAE Wangerin

Shrubs with alternate leaves and deciduous branched or hair-like stipules. Flowers small, dioecious, 3–5 merous, the calyx obsolete, in small epiphyllous umbels. Ovary 3- or 4-locular. Fruit drupaceous, separable into 3 or 4 one-seeded cartilaginous or leathery nutlets. Wood diffuse porous with slight tendency to semi-ring porous. Vessel elements angular to rounded in outline, mostly with thin and even walls and scalariform to elongate-elliptic side-wall pits and occasional tertiary spiral thickening. Perforation plates scalariform, mostly few-barred, the end walls steeply inclined. Rays of type Heterogeneous I.

The tribe Helwingieae consists of the genus *Helwingia* Willd. with three species in Japan, China and the Himalayas. Both morphologically and anatomically the tribe displays an interesting assortment of primitive and derived features. The tendency to a reduced but variable number of floral parts, the few-flowered umbellate inflorescence and dioecism are marks of derivation, possibly recent. These gross evidences of relative advancement are accompanied by anatomical features which also suggest a transition to a higher state of specialization. This is noticeable in the slight tendency to semi-ring porosity of the wood, and the occurrence of some unevenly thickened vessel walls which occasionally have tertiary spiral thickenings. Similarly, the scalariform perforations are few-barred, the average for the tribe being 23. Fibrous elements are approximately equally fiber-tracheids and libriform fibers with a few of these septate. However, the multilocular ovary and separable 1-seeded nutlets are clearly primitive, as are such anatomical characters as the scalariform to elongate-elliptic side-wall pits and steeply inclined (average 10°) end walls of vessel elements. Averages for vessel element length and width are 670μ and 32μ respectively. Although the vessel elements are considerably shorter than the average for Cornoideae and for Cornaceae the small diameter gives a length-width ratio of about 21:1. It seems evident that Helwingieae must be regarded as a fundamentally primitive group in Cornoideae which has made moderate advances in a few morphological and anatomical characters.

Variation in anatomical characters among the species is shown in the following table.

Helwingia chinensis Batalin (NY—*Ho-Chang Chow 666*); *H. japonica* Dietr. (NY—*Kanehira 3434*); *H. himalaica* Hook. et Thoms. (NY—*Henry 11992*; US—*Henry 6719*.)

	H. chinensis	*H. japonica*	*H. himalaica*
Vessel length			
Max.	903μ	772μ	917μ
Min.	451μ	537μ	301μ
Av.	729μ	665μ	616μ
Vessel diam.			
Max.	43μ	41μ	32μ
Min.	28μ	31μ	20μ
Av.	36μ	34μ	27μ
Ratio	20:1	19:1	22 5:1
Perforation			
% Scal 31 + bars	0	0	15
% Scal. 30 − bars	100	100	85
Av. no. bars.	20	26	24

Tribe TORRICELLIEAE Wangerin

Small trees with alternate palmately veined, long-petiolate leaves, the petiolar base expanded at junction with stem. Flowers small, dioccious, in long, lax many-flowered panicles. Pistillate flowers apetalous, on bracteolate, articulate pedicels. Ovary 3- or 4-locular. Fruit a 1-seeded drupe. Wood ring porous, the late wood pores in irregular tangential bands of clusters and 2–5 multiples. Vessel elements round in outline, unevenly thick walled, the side walls densely alternate and bordered pitted and mostly with tertiary spirals. Perforations simple porous, the end walls nearly transverse in spring elements. Rays of type Heterogeneous IIA.

The tribe Torricellieae consists of the single genus *Torricellia* DC. with two or three species of tropical or temperate central and eastern Himalayas. Anatomically, the tribe stands well apart from and in advance of other tribes in the subfamily. The ring porosity of the wood is conspicuous and unique. The simple-porous vessel elements are very short and relatively broad, giving a length-width ratio of 5.6:1, the lowest for Cornaceae. Vessel element end walls are inclined to the long axis of the cell at an average angle of 40°, those of the spring wood being almost transverse. Most vessel elements possess a tertiary spiral thickening. Fibrous elements are exclusively libriform, predominantly septate and very short, averaging 855μ. The over-all character of the wood is suggestive of araliaceous affinities. Morphologically, the lax paniculate inflorescence and 3- or 4-locular ovary are relatively primitive. The tribe appears to represent the culmination of a long and rather independent line of evolution in which the more striking advances have been made along anatomical lines.

The following chart shows the extent of anatomical variation.

Torricellia angulata Oliv. (US—*E. H. Wilson 2349, 4611*). *T. angulata* var. *intermedia* (Harms) Hu (NY)—*Petelot 6363*; Y #21773 (as *T. "arguta"* var. *intermedia*)—Fan Mem.

	T. angulata
Vessel length	
Max.	681μ
Min.	268μ
Av.	444μ
Vessel diam.	
Max.	192μ
Min.	31μ
Av.	78μ
Ratio	5.6:1
Perforation	Porous

Tribe GRISELINIEAE Wangerin

Shrubs, trees or scandent epiphytes with alternate sometimes coriaceous leaves. Flowers hermaphrodite or dioecious, 5-merous, the pistillate sometimes apetalous, in simple terminal or axillary racemes, clusters of racemes, or panicles. Ovary 1- or 2- (rarely 3-) locular with single ovule in each locule. Fruit a berry (unknown in *Melanophylla*). Wood diffuse porous with little or no wood parenchyma. Vessel elements rounded angular in outline with thin and even or slightly thickened and uneven walls and elongate-elliptic and round side-wall pits. Perforation scalariform with few bars, or simple porous. Rays of type Heterogeneous I.

The tribe Griselinieae consists of *Griselinia* Forst. with about six species in New Zealand, Chile, and Brazil and *Melanophylla* Bak. with possibly three species confined to Madagascar.

On consideration of general morphological and anatomical characteristics the two genera seem to constitute a satisfactory tribal group whose general position in Cornoideae is relatively primitive.

Griselinia is the less specialized genus of the tribe. Average vessel element length is 1062μ and average width is 55μ, giving a rather high length-width ratio of about 21:1. Perforations are exclusively scalariform with an average of 16 bars per plate, none having in excess of the median 31 bars. With the exception of one of the species studied, the inclination of the end wall to the long axis of the vessel element is somewhat less than 12°. Vessel side-wall pits are predominantly round. Fibrous elements are mostly fiber-tracheids and these are non-septate. In addition to the reduced bar number in perforations, the chief evolutionary advance has been morphological with the development of dioecism and a 1-locular ovary.

Variation in anatomical characters among the species is shown in the following table.

Griselinia littoralis Raoul (NY—*Meebold 4103;* Y #6601); *G. lucida* Forst. (Y #37882); *G. jodinifolia* (Griseb.) Taub. (CNC—*Junge* in 1932; US—*Buchtien* in 1898); *G. racemosa* (Phil.) Taub. var. "hojas acumiana" (US—*Buchtien* in 1898).

	G. littoralis	*G. lucida*	*G. jodinifolia*
Vessel length			
Max.	1441μ	1768μ	982μ
Min.	537μ	1244μ	713μ
Av.	905μ	1447μ	835μ
Vessel diam.			
Max.	82μ	130μ	37μ

	G. littoralis	*G. lucida*	*G. jodinifolia*
Min.	23μ	62μ	23μ
Av.	44μ	90μ	31μ
Ratio	21:1	16:1	26:1
Perforation			
% Scal. 31 + bars	0	0	0
% Scal. 30 − bars	100	100	100
Av. no. bars.	19	14	16

Material of *G. racemosa* was too young for vessel measurements, but was in agreement with other species in all other anatomical characters except that number of bars per perforation plate averaged 31.

In contrast to *Griselinia* the flowers of *Melanophylla* are hermaphrodite and the ovary is 2- or 3-locular. Its anatomical position, however, is more advanced. Vessel elements average 759μ in length and 53μ in width. While the average width is not significantly different from that of *Griselinia*, the length-width ratio is markedly advanced, being about 14:1. Perforations of vessel elements are chiefly of two types, scalariform, and simple porous with some intermediate scalariform porous. [cf. Wangerin, 1906, in Engl. Bot. Jahrb. *38*.] The scalariform perforations have an average of 15 bars Simple porous perforations constitute about 16% of the total. Inclination of vessel element end walls averages 15°. Vessel side-wall pits are chiefly round with some of the elongate-elliptic type. Fibrous elements are about equally fiber-tracheids and libriform fibers, about half the latter being septate.

In view of the striking contrast in evolutionary accent in *Melanophylla* and *Griselinia* it seems clear that their development has been parallel from a more primitive stock derived in its turn from the main cornoidean line.

Variation in anatomical characters are shown in the following table.

Melanophylla alnifolia Bak. (P—*Baron 3240*); *M.* sp (P #517—*Humblot* in 1883).

	M. alnifolia	*M.* sp.
Vessel length		
Max.	1021μ	753μ
Min.	674μ	425μ
Av.	890μ	626μ
Vessel diam		
Max	62μ	57μ
Min.	46μ	46μ
Av	54μ	51μ
Ratio	16:1	12:1
Perforation		
% Scal. 31 + bars	0	0
% Scal. 30 − bars	82	85
% porous	18	15
Av no. bars	16	13

CONSIDERATIONS OF PHYLOGENY

From consideration of the facts of morphology and anatomy, it is clear that the family Cornaceae is a fairly homogeneous group, with few discordant ele-

ments, and probably is correctly estimated as the primitive family of the traditional Umbellales. In floral pattern a high degree of constancy has been achieved with constant and complete epigyny, 4 or 5 (very rarely 3 or 6) calyx lobes, petals and stamens, and 1- to 4-celled ovary. Flowers are uniformly small and borne in a series of inflorescence patterns from open paniculate types to condensed and specialized cymes resembling umbels or small capitula. Fruits are drupaceous or rarely baccate, the seed endospermic with small embryo. In anatomical characters of the wood, similarly, a number of important characteristics are constant features of the family. These, along with the constant morphological characteristics emphasize the evident homogeneity. Thus, the diffuse porous wood with sparse and diffuse wood parenchyma, rays of similar heterogeneous types, and vessels with scalariform perforations are, with very rare exceptions, constant for the family.

These facts may be urged in support of a monophyletic origin for the Cornaceae or may indicate merely the attainment of a rather uniform level of evolutionary development by the existent genera. Wangerin's recognition of three subfamilies chiefly on the basis of the relative position of the micropyle of the anatropous ovules permits the division of the family into two groups consisting of Mastixioideae and Curtisioideae in which the micropyle is extrorse, and Cornoideae in which it is introrsely situated. What phylogenetic significance attaches to this characteristic is unknown, but it combines with the development of secretory ducts in *Mastixia* to give Mastixioideae a unique position within the family. It has been suggested by others that *Mastixia* may represent a link between Cornaceae and Araliaceae, or possibly that a *Mastixia*-like form served as a common ancestor of the two families. With the exception of the regularly unilocular ovary, which is doubtless the result of relatively recent reduction, *Mastixia* is clearly very primitive. This is well substantiated by the evaluation of anatomical characteristics. Curtisioideae, although allied with Mastixioideae by the character cited above, is without secretory tissue, and thus appears to stand in an intermediate position between Mastixioideae and Cornoideae. Anatomical data also clearly suggest this. The number of floral parts has been reduced to 4, although the primitive 4-locular ovary has been retained. The subfamily Cornoideae, in its average expression, represents a third and higher degree of specialization. Morphologically, it has attained in some genera a reduction of number of floral parts to 3, the dioecious condition, unilocular ovary, and highly specialized inflorescence patterns. Anatomically, it displays the most highly specialized conditions.

It seems most fruitful to view the three subfamilies as the culminations of three essentially separate lines of evolutionary development which had their origin in some remote, possibly single, ancestral type. Fig. 2, based upon anatomical and morphological data, is intended to express the inter-relationships among the subfamilies, tribes and genera. The range of anatomical variation is approximately indicated by the vertical dimension of the rectangles enclosing generic names. *Mastixia* and *Curtisia* pursued parallel courses, the latter attaining a somewhat more highly specialized condition, anatomically. The developmental line leading

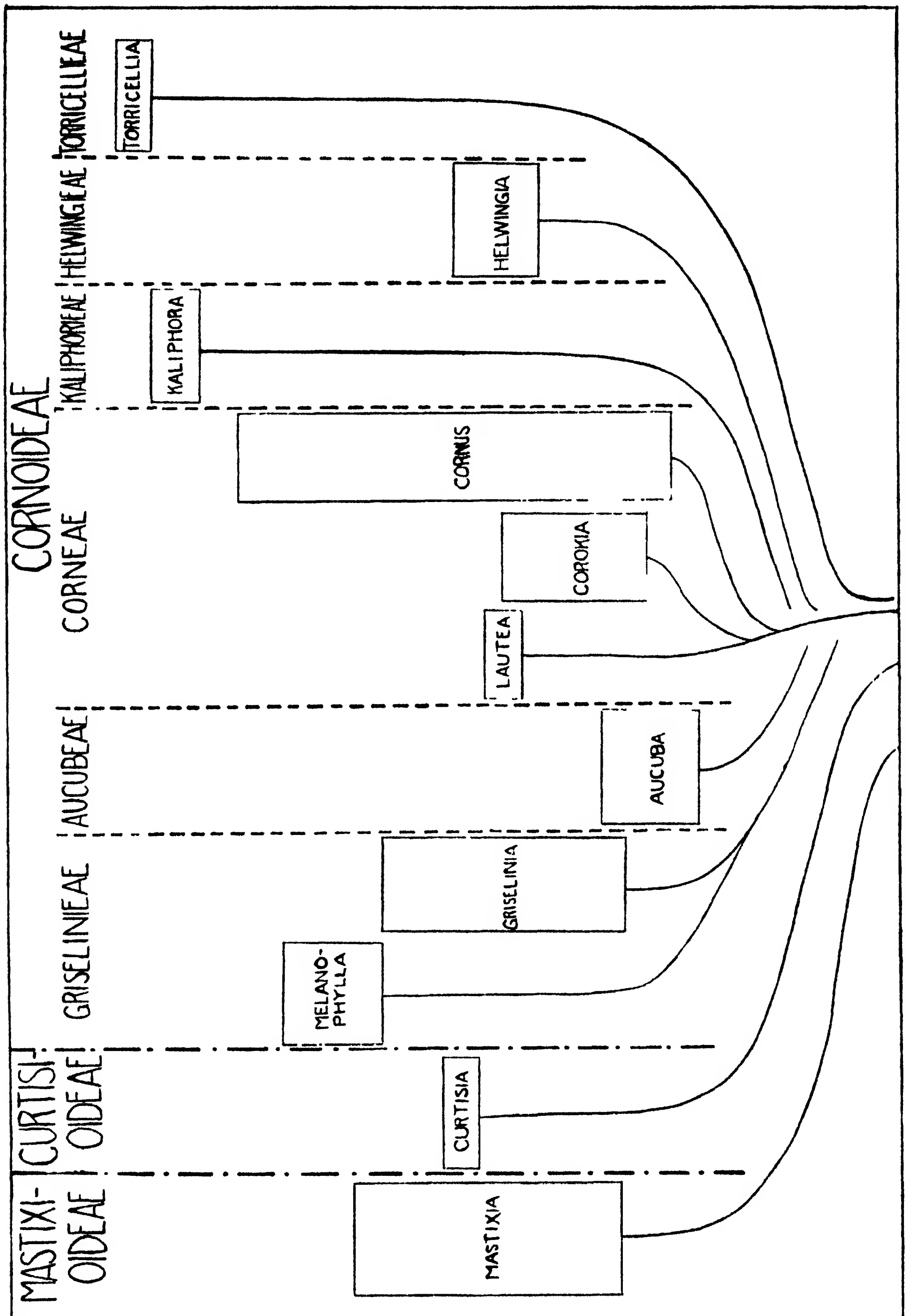


FIG. 2. Phylogenetic relationships among genera and tribes of Cornaceae

to Cornoideae was abruptly divergent from the other two and demonstrated considerable evolutionary vigor as evidenced by the number of its constituent genera. The tribe Corneae, consisting of *Lautea*, *Corokia*, and *Cornus* represents the main trend of the cornoidean line.

Lautea and *Corokia*, although morphologically primitive in the tribe, are anatomically more specialized than some of the species of *Cornus*. Therefore, *Cornus* must have been differentiated from the cornean stem at an early period.

The tribe Aucubeae is regarded as a fundamentally primitive offshoot from the cornoidean line at a point somewhat below the Corneae. Its primitive position rests chiefly upon vessel characteristics, baccate fruit and inflorescence pattern. Spiral tertiary thickening of vessel walls and some fibers, rays of a derived type, and the tendency to semi-ring porous wood are the results of precocious and possibly recent anatomical development. The unilocular ovary, tetramery and dioecism are similarly regarded.

Kaliphora is most closely related to the Corneae. Its long evolutionary history has produced a degree of specialization in all anatomical and some morphological characters, well beyond that attained by the Corneae. It has retained as evidence of its great age, a primitive inflorescence pattern and separable drupaceous fruit.

The tribe Helwingieae, variously considered in and out of Cornaceae by earlier systematists, is conspicuous by virtue of its stipules and epiphyllous inflorescence. The 3- or 4-celled ovary and fruit with 3 or 4 separable nutlets suggest that it may have arisen from the differentiating cornoidean line at about the point of origin of *Kaliphora* but somewhat earlier. Active reduction of flower parts seems to be in progress. The umbellate inflorescence is probably not closely related to the similar pattern in *Cornus*, and the adnation of peduncle to leaf is of little or no phylogenetic significance. The tribe is anatomically predominantly primitive but displays a variety of transitional conditions and advanced features that are quite in keeping with the progressing morphological changes. The stipules of *Helwingia* may be a mark of relationship to Araliaceae.

In anatomical characters *Torricellia* is the most highly specialized genus in Cornaceae. Its lax paniculate inflorescence, pentamerous (though reduction is in progress) and multilocular ovary are primitive characters suggesting a long developmental history. To establish a satisfactory point of departure from the line of the Cornoideae is difficult. The wood structure suggests possible affinity with certain araliaceous genera, and the expanded petiolar bases resemble those of Araliaceae. It seems best to suggest that it originated at a very remote time, pursued a course parallel and close to the cornoidean line and diverged therefrom prior to the differentiation of other cornoidean tribes.

In the tribe Griselinieae *Melanophylla* is considerably more advanced than *Griselinia* in anatomical characters, these advances are, for the most part, extensions of tendencies manifest in the latter. *Melanophylla* has retained certain primitive features of flower structure not shared by *Griselinia* and must, therefore, have arisen at a relatively early period in tribal development. *Griselinia*, meanwhile, has made notable morphological advances, notably in reduction of ovary to one cell.

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STUDIES IN THE WOODY ANATOMY OF THE FAMILY NYSSACEAE

By Paul Wilson Titman

Department of Botany, University of North Carolina
Chapel Hill, North Carolina

INTRODUCTION

The systematic position of Nyssaceae has been as varied, almost, as the systematists who have considered this problem. This is, at first glance, surprising since the family contains only three genera including from twelve to possibly fifteen species. Only one genus, *Nyssa*, has a wide distribution. This genus is found in eastern North America with perhaps six species, one of which, *N. sylvatica* Marsh., is quite widespread; as it has been reported, recently, in Mexico in an extension of the range along the Gulf coast. The other two genera, *Davidia* and *Camptotheca*, which are generally considered monotypic, are to be found endemic in the eastern border of Tibet, subtropic China and into the monsoon belt. This range is shared with the remaining species of *Nyssa*. The family members are, so far as is known, trees of relatively great height, with the exception of *N. acuminata* Small and *N. ursina* Small, both native to Florida and described by him (1933) as shrubs less then three meters in height.

The floral parts are highly variable in the family. The family may be considered as polygamo-dioecious, or possibly dioecious in some instances. The pistillate flower of *Camptotheca* is still imperfectly known. The carpel number varies from one to ten. The floral parts seem to be basically pentamerous with wide variation from this number. The perianth varies and is frequently reduced to a weakly toothed fringe of scales varying in number. The fruit is drupaceous throughout and one- to five-seeded.

The variability of the family characters is reflected in the placement of the family and the genera. Bentham and Hooker (1883), for example, place *Nyssa* in Cornaceae as does Harms (1898). Engler (1909) places Nyssaceae in the Myrtales between Rhizophoraceae and Alangiaceae, while Baillon (1877) places *Nyssa* in Combretaceae. Endlicher (1838) removed *Nyssa* from Cornaceae and recognized the family Nyssaceae which he places near the Santalaceae. Wangerin (1910) maintains the family Nyssaceae and says in reference to its placement that the family was separated from the Cornaceae on the basis of diplostemony and the presence of a double integument about the ovule. Wangerin states that while *Nyssa* and *Camptotheca* are apparently closely related, *Davidia* seems hardly closer to them than it does to Cornaceae but that it is given provisional accommodation within the family since it does not seem to fit any better into any other family.

Data of an anatomical nature have been meagre and of a very general sort. Solereder (1908) treats the three genera in his consideration of Cornaceae but makes no specific reference that is applicable. Much of the information he gives

is based on the work of Wangerin, and since Wangerin has made the most exhaustive study of the family in general, his treatment in Das Pflanzenreich was utilized considerably by the writer in the prosecution of this study. Anatomical evidence in application to problems in systematics has been utilized by Tippo in his studies of Moraceae (1938) and by others. It is the purpose of the present study to arrive at some concept of the intergeneric relationships of Nyssaceae preliminary to a possible subsequent revaluation of the systematic position of Nyssaceae among its presumed allies.

MATERIALS AND METHODS

Collections of stems evidencing both primary and secondary growth were obtained from the University of North Carolina Herbarium (CNC), the Herbarium of the New York Botanical Garden (NY), and The United States National Herbarium (US). In addition, fresh material was collected by the writer (auth.) wherever possible and blocks of secondary xylem obtained from the Yale School of Forestry (Y) were studied.

Sections and macerations were made of secondary wood. Tissue was softened with glycerine, alcohol, and water mixture and sectioned at 12 microns in radial, tangential, and cross sections on the sliding microtome, stained with safranin and mounted in Euparal.

The maceration of tissues was effected by a modification of Jeffrey's technique. The tissue was shaved into small chips and soaked in a 1% Tergitol solution for 24 hours after which it was left in Jeffrey's maceration fluid diluted to 50% with distilled water and placed in a warming oven for four to twelve hours. This treatment separated the tissues thoroughly without causing the disintegration of cells that sometimes occurs when the maceration fluid of full strength is used. The maceration fluid was quickly removed with water in repeated washings and the material concentrated by centrifugation. When the fluid containing the macerated tissue no longer gave an acid-positive litmus reaction, it was assumed that all maceration fluid was removed and the macerated tissues were stored in vials of glycerin-alcohol-water with about one drop of safranin per cubic centimeter of solution until required for observation.

The traditional basic dicta for the comparative study of secondary wood elements were considered with certain modification in the observation of this material. These dicta, derived chiefly from the work of Gilbert, Frost, Kribs and others, have been fully discussed by Cox (1948).

The cross sections of wood blocks were used to obtain the type of porosity, the shape of the vessel in cross-section and the wood parenchyma distribution. Tangential sections were used to determine the medullary ray type and the inclination of the end wall of the vessel to the side wall. Radial sections were used to check the medullary ray determinations and to study intercellular pitting. Semi-permanent mounts were made of macerated material and the following data were collected therefrom. The scalariformity, number of bars per plate, the maximum diameter, diameter at midpoint, vessel length, degree of bar borders, and side-wall pitting was determined for each vessel and recorded

for the average. The fiber length and type were determined from macerated material also.

The length-width ratio of the vessel cited for the species was computed by determining the average width and length of the specimens and computing the average width and length of the species from these figures. The ratio was then obtained by dividing the average species length by the average species width. The ratio characteristic is an application of the data of Cox (1948). If two compared forms are equal in average vessel lengths but with a different ratio in average vessel length to width, all other vessel structures being equivalent, the form with the lower ratio is considered advanced. The range of length to width ratios for the family is from 7:1 to 35:1, a considerable range.

A wide range in the number of bars in the perforation plate was found. The averages varied from 25 to 75 for genera within the family. An arbitrary mid-point of 52 was set as a line of separation between the primitive many-barred and the advanced few-barred condition within the family limit.

The end-wall angle was found to range between 10° and 25°. The arbitrary mid-point of 16° was set up as a line of separation between primitive narrow-angled and the advanced (or derived) wide-angled end walls, within the family limits, and the figures are so indicated in Table 3.

The average was derived from forty to fifty units for the computations of each specimen and the minimum and maximum figures for each were also recorded. The units were remarkably uniform within any particular specimen. Since, with very few exceptions, there were at least two specimens representing each species (and sometimes more), actually between eighty to a hundred units were measured for the average figure utilized in the individual species and it is this final average that is set down in Table 3.

The general condition of Nyssaceae as indicated by wood characters appears to be primitive. The family was found to be consistent and uniform in the following characters:

1) The absence of ring porosity.
2) The presence of scalariform perforation.
3) Opposite side-wall pitting with an occasional scalariform lateral.
4) Absence of tertiary thickening of vessel walls.
5) Small clusters of vessels at most.
6) Diffuse and sparse xylem parenchyma.
7) Absence of Homogeneous medullary ray types.
8) Inclination of end wall of less than 26°.

It is apparent that with minor variation, these consistencies are generally primitive in nature. It is necessary, then, to consider the variation in other vital characteristics. The number of bars in the perforation plate, the diameter and length of vessel segment and their ratio, and other variations were studied carefully in order to ascertain the relative primitiveness of the genera and the species, from an anatomical viewpoint.

Evaluation of the species in anatomical terms was then compared with the morphological data and characteristics. This morphological information was

obtained from the various descriptions of the family members available and evaluated according to the morphological characteristics set forth in the precepts of morphological evolution as laid down by Hutchinson (1926). Those precepts particularly applicable to the present case may be summarized as follows:

1) Bisexual flowers precede unisexual flowers.
2) Polycarpy precedes oligocarpy.
3) Many stamens are more primitive than few stamens.

The precepts are of a general nature and external conditions may cause variation that is not of evolutionary significance. A comparison of the members of the family was attempted with the knowledge that there would be individual variation, as not all elements change at the same rate within the phylogeny of a group. An effort is made to correlate the anatomical details of Nyssaceae with the morphological data. With such an integration it is believed that a clearer picture of inter-relationships within the family may be obtained. The anatomical evidence is considered to be of a confirmatory nature wherever morphological evidence is adequate and in no case is it attempted to supplant morphological evidence.

DISCUSSION

Nyssaceae is a small but widely varied family. The family consists of trees (only two species are described as shrubs) and is to be found in eastern United States, along the Gulf coast and the temperate and sub-tropical area of Asia and the adjacent islands. No other areas of distribution are known with the possible exception of a generally discredited species described as growing in New Guinea (*Nyssa Hollrungii* Schum.). The flowers are regular, pentamerous, hypogynous, bisexual or unisexual, polygamo-dioecious or dioecious, with stamens as many or twice as many as sepals or petals or fewer, rarely more. Petals and sepals are frequently reduced and occasionally missing. The anthers are introrse, opening by slits. The gynoecium is one-carpellate with a one-celled ovary containing one ovule, to ten-carpellate, with a corresponding number of cells, each with one ovule. The ovules are pendulous from the top of the cell. Wangerin and others have stated that two integuments are present but the writer was unable to demonstrate the presence of more than one integument in the fruits of *Nyssa* species available, even when the fruits were very young. The style is simple and stigmatic on the inner surface or with as many branches as carpels. A disk is frequently to be found on the ovary. The fruit is drupaceous.

Anatomically, the family is consistent in 1) being diffuse porous, 2) unevenness of vessel walls, 3) vessel end wall with an angle of less than 26°, 4) scalariform bars in perforation plates averaging seventy-five or less per plate, 5) elongate-elliptic side-wall pits with rare lateral scalariform ones, 6) absence of tertiary thickening (rare tertiary thickening at the very tips of vessel segments as indicated by Record and Hess, 1943, p. 411, in *Nyssa*, was not observed by the writer), 7) absence of septate fibers. Other anatomical features which are

present but not common to the various family members will be considered in a diagnostic discussion of the various species and genera.

The three genera will be treated separately in what appears to be the correct phylogenetic sequence. There is some confusion in nomenclature of the species of this family. Specimens were occasionally received under synonymous names and in such cases the synonym is included in parenthesis before the specimen listing.

Sub-Family DAVIDIOIDEAE Harms

Inflorescence inclosed in two involucres. Stamens 1–7 on staminate and pistillate flowers according to Wangerin (1910) and Rehder (1930), but Johnson (1931) claims that the staminate flower has only one stamen per flower. There is a general reduction of petals and sepals to obscurity. The bisexual flower is to one side of the common receptacle of the inflorescence with a 6–10-carpellate gynoecium with inferior ovary supporting a style bearing radiate stigma branches equal in number to the number of carpels. The fruit is a drupaceous berry. The wood is diffuse-porous with vessels oval-angular in outline, thick and uneven in wall, with an average diameter at the mid-point of 44 microns, a minimum of 39 microns and a maximum of 65 microns, and an over-all average length of 1341 microns with a minimum of 1172 microns and a maximum figure of 1572 microns, and length to width ratio of 30:1. The angle of the end wall to the side wall is 12° and the perforation plate has an average of seventy-five bars per plate. The fibrous-elements are largely fiber-tracheids and the medullary rays are Heterogeneous I.

DAVIDIA Baillon

D. involucrata Baill.: *R. E. Ching 5214* (NY); *Y. Tang* (Y 29792). *D. involucrata* var. *Vilmorniniana* Wang.: *G. Forrest 26541* (NY); *J. F. Rock 10238* (US 1511149); *J. F. Rock* (US 1511150); Cultiv. at Ann Arbor 5159 (Y 29360); Cultiv. at Kew (Y 12683).

There is only one species, *D. involucrata* Baillon (Adansonia **10:** 114, 1871) for which the above description will suffice. This species is to be found in Tibet and central China. There is one good variety, *D. involucrata* var. *Vilmoriniana* (Dode) Wangerin, which varies only in the glabrous quality of the mature foliage. This variety is to be found in subtropic central China.

This sub-family is, in its floral characteristics, primitive, having the only considerable number of carpels in the family and the most nearly perfect flowers. This primitive position is well borne out anatomically. Particularly significant is the medullary ray type, there being no other member of the family having the primitive Heterogeneous type I ray. The length of the vessel element is the longest of the family and the ratio of length to diameter in the vessel, is highest in the family. The end-wall angle is the narrowest of the family and the perforations of the vessel plate are greatest in number in the entire family, viz. seventy-five. The only anatomical precocity of the genus is evidenced in a

tendency to oval outline of vessels, uneven walls, and occasional libriform fibers. The findings may be studied in detail in Table 3.

Sub-family NYSSOIDEAE Harms

Polygamo-dioecious or dioecious. Staminate flowers with five sepals and five alternately arranged petals variably reduced. Stamens are ten in number with apparent diplostemony. No ovarian rudiments are to be found as a rule in the staminate flower. The pistillate flower is hermaphroditic, with varying abortion of the androecium. The ovary is inferior with one to two cells, maturing into a drupaceous fruit. Although the occasional finding of two-seeded fruit in *Nyssa* is doubted by Wangerin, this writer has discovered that to be the case in infrequent occurrence. The wood is diffuse porous with thick or thin uneven vessels angular to oval-angular in outline with end-wall angle from 11° to 25°. Vessel perforation plates are scalariform with a range of specific average of bar number from 25 to 59. Tertiary thickening is absent. The medullary rays are type II A or B Heterogeneous.

NYSSA L.

Polygamo-dioecious with staminate flowers numerous, carpellate flowers solitary or in clusters of two or three. The perianth is occasionally reduced or partially absent with a rudimentary gynoecium rarely found in staminate flowers. The stamens are in two circles inserted under a disk, with thin elongate filaments and introrse elliptic-round anthers opening by a long split. The writer has discovered that the five to ten stamens of the hermaphroditic flower occasionally bear functional pollen grains. The hermaphroditic flower has five sepals and five alternate petals with a unicarpellate pistil and a one-celled ovary crowned with a disk. The fruit is drupaceous with a hard seed that has ridges varying from rounded to winged. On the basis of these ridges and their variations, Coulter separates the genus into two groups (1890). Wangerin (1910) divides the genus roughly into the same groups but on the basis of the inflorescence type of the male flower, and Small (1933) divides the genus into two similar groups, largely on the basis of the type of the female inflorescence. The genus varies anatomically. The wood is diffuse-porous with vessels that are angular to oval in outline, thick- or thin-walled and consistently uneven in cross section. The ratio of vessel dimensions varies from 7:1 to 35:1, and the angle of the end wall to the side wall varies from 11° to 21°. The perforation plate is consistently scalariform with the number of bars varying from 26 to 59. The fibers are occasionally libriform and the medullary ray type varies from Heterogeneous II A to Heterogeneous II B.

Of the specimens obtained, seven possible species are considered. Synonyms are given in parenthesis in the treatment of specimens when they were received under those synonymous names. Many described species are not recognized at present, and three species which are recognized as valid according to Index Kewensis (Vol. II and supplements 1885–1940), *N. arborea* Koord (1912). *N. megacarpa* Parker (1927), and *N. Hollrungii* Schum. (1912), were not available

to the writer. *N. Hollrungii* is considered dubious by Wangerin on the basis of the absence of endosperm, and it is now believed to be in Alangiaceae.

Wangerin placed the members of this genus in two sections, according to the inflorescence of the male flower. These sections he called Pedicellatae and Capitatae, respectively, following Harms in this classification. An anatomical comparison was attempted between the various members following Wangerin's morphological classification. Five species (*N. aquatica* L., *N. biflora* (Walter) Sargent, *N. sylvatica* Marsh., *N. sinensis* Oliver, and *N. ursina* Small) were found to meet the morphological requirements of the Pedicellatae.

PEDICELLATAE Harms

Anatomically, *N. ursina*, *N. sylvatica*, and *N. biflora* have the slightly more advanced medullary ray type Heterogeneous II B as opposed to Heterogeneous II A in the remaining two species. All in all, anatomical indications are that *N. sinensis* with Heterogeneous type II A rays, angular vessels with low-angled end walls, above the average number of bars and fiber-tracheids, is the most primitive of the section. In no case does this species have an individual advanced anatomical feature, but it does have a primitive group of characteristics unequalled in the section. *N. sylvatica* seems to be the most primitive of the American species in this section with *N. aquatica* the most advanced of the section from an anatomical standpoint, for it has only one primitive feature that is not shared by the entire family, medullary ray type Heterogeneous II A, and a number of relatively advanced characteristics larger than any other species of this section. (See Table 3.)

The individual species of the Pedicellatae may be described as follows:

Nyssa sinensis Oliver

The inflorescence is umbel-like tending towards a shortened raceme. Staminate flowers have minute calyx lobes, narrow petals, and five to ten stamens inserted on a disk. Pistillate flowers have a minute bract, an inferior ovary and a 2–3 mm.-long style. The fruit is drupaceous. Diffuse wood with fiber-tracheids and Heterogeneous type II A medullary rays is present. The vessels are angular to oval-angular in outline with thin but uneven walls, have an average diameter at the mid-point of 91 microns with a minimum diameter of 72 microns and a maximum diameter of 108 microns and an average length of 1014 microns with a minimum length of 917 microns and a maximum length of 1382 microns. The length to width ratio is 11:1. The end-wall angle is 13°, and the perforation plate bears an average 53 bars.

Nyssa sylvatica Marsh

Staminate flowers are in five-to twelve-flowered racemes with calyx lobes reduced to teeth, have five petals and stamens equivalent in number to that of the perianth lobes. There is a rudimentary style occasionally in the depressed central disk. Pistillate flowers are sessile in a head and usually three in number. The ovary is inferior. In the pistillate flower, which is supported by two basal

bracts covered with hair, there are approximately five sepals and no petals and five to ten rarely fertile stamens. The fruit is a drupe. The wood is diffuse-porous with fiber-tracheids and medullary rays of type II B with vessels of angular outline, thin but uneven walls, an average over-all length of 1309 microns with a minimum length of 1033 microns and a maximum length of 1544 microns and an average diameter at the mid-point of 67 microns with a minimum diameter of 45 microns and a maximum diameter of 120 microns and a length to width ratio of 19:1. The end wall angle is 11° and the perforation plate averages 52 bars.

Nyssa biflora (Walter) Sargent

This species varies morphologically from *N. sylvatica* only in the leaf form, which is spatulate as opposed to oval in *N. sylvatica*, and in the more pronounced ridges of the stone. The female flowers are borne in pairs rather than in threes. The range of *N. biflora* is distinctive, being the coastal swamp area of south-eastern United States. Anatomically, it differs from *N. sylvatica* very little. Whereas the average vessel length of *N. sylvatica* is 1309 microns, that of *N. biflora* is 934 microns. *N. sylvatica* has an average diameter at the mid-point of the vessel of 67 microns while *N. biflora* has an average diameter of 46 microns. The minimum and maximum figures for *N. biflora* are: diameter, 45 microns and 85 microns; and length, 831 microns and 1260 microns. Thus the length to width ratio of *N. biflora* is 20:1 as opposed to 19:1 for *N. sylvatica*. The end-wall angle is 14° compared to 11° in *N. sylvatica* and the number of bars on the perforation plate average 59 as against 52 for *N. sylvatica*.

Nyssa ursina Small

This is a shrub with very numerous leaves and flowers and later clusters of globular drupes. The ratio of vessel length to width was 35:1, the highest ratio of any species in the family. Otherwise no significant data were to be derived from the inadequate specimen available. (See Table 1.)

Nyssa aquatica L. (*N. uniflora* Wang.)

The species has very large leaves (9–30 cm.) with a purple-blue drupe that contains a sharp-ridged stone. The pistillate flower is borne singly on a short pedicel. The wood contains Heterogeneous II A medullary rays. Vessels are oval in outline, with thick uneven walls, average diameter at mid-point of 75 microns, minimum diameter of 59 microns and a maximum of 110 microns, and average length of 998 microns, minimum length of 779 microns and a maximum length of 1226 microns and a ratio of 14:1 in length to width. The end-wall angle is 21° and the perforation plate bears an average of only 34 bars. The fibers are occasionally libriform.

The following specimens were studied.

N. sinensis Oliver: *H. H. Hu 043* Fan Mem. Inst. (Y 21459). *N. sylvatica* Marsh.: Cultiv. Ann. Arbor 220a–1 (Y 19479); Author's collections. *N. biflora* Walt.: *J. L. Stearn* (Y 40120); *H. A. Burlage* (CNC 12037); *H. A. Burlage* (CNC

10332); *Ashe* (CNC) (*multiflora*). *N. ursina* Small: *Ashe* (CNC). *N. aquatica* L.: *Millspaugh* (Y 11730); *US* (Y 39419); *H. A. Burlage* (CNC 23652).

CAPITATAE Harms

The Capitatae are those species with the male inflorescences capitate, a condition considered higher than that characterizing the Pedicellatae. The section is represented by three good species: *N. javanica* (Blume) Wangerin (*N. sessiliflora* Hook. and Thomps.), *N. ogeche* Marsh, and *N. acuminata* Small. *N. acuminata* was not available for study.

TABLE 1

Anatomical characteristics of Pedicellatae

	N. SINENSIS	N. SYLVATICA	N. BIFLORA	N. URSINA	N. AQUATICA
Medullary rays Hetero. II	A	B	B	B	A
Vessel outline	Oval	Angular	Oval	Angular	Oval
Wall	Thin	Thick	Thick	Thin	Thick
Diam. at mid-point					
Min.	72	45	45	—	59
Ave.	91	67	46	—	75
Max.	108	120	85	—	110
Length					
Min.	917	1033	831	—	779
Ave.	1014	1309	934	—	998
Max.	1382	1544	1260	—	1226
Ratio	11:1	19:1	20:1	—	14:1
End-wall angle	13°	11°	14°	16°	21°
Ave. no. of bars	53	52	59	—	34
Fiber type					
Tracheid	x	x	x	—	x
Libriform		x	x	—	x

Nyssa javanica (Blume) Wangerin

The staminate flowers have irregular calyx lobes usually five in number with five alternate obovate petals and ten stamens in two series. The pistillate flower has the ovary surmounted by a disk and has a simple style. The medullary rays are of Heterogeneous II A type and the vessels are oval in outline, thick and uneven in wall and with a diameter at the mid-point averaging 156 microns with a minimum figure of 115 microns and a maximum figure of 190 microns. The average length for the vessel is 1219 microns with a minimum length of 1101 microns and a maximum length of 1919 microns, giving a length to width ratio of 9:1. The angle of the end wall is 19° and the perforation plate bears an average of 48 bars. The fibers are occasionally libriform.

Nyssa ogeche Marsh

The staminate flowers are sessile in well developed heads. The calyx is very small and reduced. Four to five petals are present and eight to ten stamens in

two series with elongated filaments and elliptical anthers. The pistillate flowers are hermaphroditic, solitary, and subtended by stipitate bracts. The calyx lobes are much reduced and the five petals are small. Five to ten stamens are inserted in a conspicuous disk. The style is very long and incurved. The fruit is a large, red drupe with widely winged seed. The species is characterized anatomically by Heterogeneous II B medullary rays, vessels oval in outline with thin and uneven walls, a minimum diameter at the mid-point of 36 microns, an average figure of 49 microns and a maximum diameter of 68 microns and a minimum length of 697, average length of 802, and a maximum length of 1120 microns, resulting in a 10:1 length to width ratio. The end-wall angle is 19°. Average number of bars in perforation plate is 26 and libriform fibers are frequent.

TABLE 2

Anatomical characteristics of Capitatae

	N. JAVANICA	N. OGECHE
Medullary rays Hetero. II	A	B
Vessel outline	Oval	Oval
Wall	Thin	Thin
Diam. at mid-point		
Min.	115	36
Ave.	156	49
Max.	190	68
Length		
Min.	1101	697
Ave.	1219	802
Max.	1919	1120
Ratio	8:1	10:1
End-wall angle	19°	19°
Ave. no. of bars	48	26
Fiber type		
Tracheid	x	x
Libriform	x	x

The following specimens of the Capitatae were studied.

N. javanica (Blume) Wangerin: *R. C. Ching S 241* (NY); *Chun and Tsu 44231* (US 1675267); *C. Van de Koppel 3553* (Y 15457); *H. Janssonius 2377a* (Y 31024) (*N. sessiliflora*). *N. ogeche* Marsh: *J. L. Stearns 013* (Y 40124); *Ashe* (CNC 1353); *leClair* (CNC); Author's collections.

CAMPTOTHECA Decne.

There is only one species, *C. acuminata* Decne. Dode (1908) describes a new species, *C. yunnanensis*, but Wangerin makes no mention of it and it is not considered by the writer since it agrees in all significant details with *C. acuminata.* A specimen in the New York Botanical Garden herbarium labelled *C. yunnanensis* appears to be merely an immature specimen of *C. acuminata*. The genus then is considered monotypic and has the following characteristics: The flowers are

polygamodioecious. The calyx is five-toothed and there are five imbricate petals with ten stamens in two series, inserted about a disk, with quadilocular anthers dehiscing introrsely. The pollen is tri-pored. The inferior short ovary is compressed. It is a rudiment in the male flower. The style is two-lobed, (very short and immersed in a disk in male flower) and Wangerin states that in spite of this there is only one locule and one seed in the fruit (Pfl. reich, IV 220A, p. 17). The wood is diffuse-porous with medullary rays of Heterogeneous type II A and fiber-tracheids, with vessels that are oval in outline with thin and uneven walls. The vessels have an average mid-point diameter of 58 microns, minimum of 50 and a maximum of 75, and an average length of 894 microns with a minimum length of 817 microns and a maximum length of 931 microns, resulting in a length to width ratio of 16:1. The vessel end wall has an average angle of 25° to the side wall and only 25 bars average per perforation plate.

These characteristics are in general advanced, and the genus is more advanced than a considerable number of the species of *Nyssa*, in most characteristics. In such a significant characteristic as the relative number of bars per perforation plate, *Camptotheca* boasts the lowest number of the entire family. It is believed logical to consider this genus as the most advanced on the above mentioned grounds. The genus appears closely related to *Nyssa* and it seems possible that the two genera may share a common ancestor.

The following specimens of *Camptotheca* were studied. *C. acuminata* Decne.: *R. C. Ching 5241* (NY); *Y. Tsiang 6286* (US 1575042); *H. H. Hu* Fan Mem. Inst. 048 (Y 21463).

CONCLUDING REMARKS

The foregoing discussion is an attempt to shed some light on the relative phylogenetic positions of the genera and species of Nyssaceae through a correlative comparison of the anatomical and morphological characteristics. It has been indicated that *Davidia* is the most primitive genus of the family and that *Camptotheca* is the most advanced, from a morphological point of view, with *Nyssa* intermediate. Anatomical characteristics, in this case, bear out the morphological suppositions with remarkably few exceptions or variations.

Of the intermediate genus, *Nyssa*, the species available were found to fall into two groups or sections, according to Wangerin. Of these two sections, the Pedicellatae is considered more primitive since the second section, the Capitatae, is characterized by an advanced feature, viz., the capitate inflorescence. The anatomical evidence does not dispute this grouping.

The consideration of the individual species of the groups anatomically as well as morphologically indicate that the most primitive species of the genus is probably *N. sinensis* with *N. sylvatica*, *N. biflora*, *N. ursina*, and *N. aquatica* following in the Pedicellatae and *N. javanica* being followed by *N. ogeche* in the more advanced Capitatae.

Since the advanced species are to be found in North America, it is suggested that the family had its origin in eastern Asia, perhaps in Central China and that the dispersal has been to the west as the family developed, with the highly de-

veloped *N. javanica* and *Camptotheca* being found in Asia as the present result of a long line of geographically stationary evolution.

It seems necessary to evaluate the findings derived from this research, particularly as it relates to *Nyssa*, the most diverse and numerous group in the family. *N. sinensis* is the most primitive member of the genus but barely more so than the geographically distant *N. sylvatica*. The indication of possibly nyssoid fossil remains in Tertiary deposits in Europe opens speculation as to the migration of a *Nyssa*-form similar to *N. sylvatica* from the point of origin to the present location of *N. sylvatica* in the wide area of eastern U. S. *N. sylvatica* is discovered to be very close to *N. sinensis* in all anatomical and morphological features. It

TABLE 3

Summary of the anatomical features of the Nyssaceae

	MEDULLARY RAY TYPE			VESSEL OUTLINE	VESSEL WALL		VES. DIAM. AT MID-POINT	VES. LENGTH	VES. RATIO	VES. END WALL ANGLE		PERF. BARS		FIBER TYPE	
	Het. I	IIA	IIB		Thin	Thick				−16°	+16°	+52	−52	Fib.-tracheid	Libriform
Davidioideae															
Davidia involucrata	x			Oval		x	42	1541	30:1	10°		75		x	x
involucrata var. Vilmoriniana	x			Oval		x	46	1141	25:1	15°		75		x	
Sub-family average	x			Oval		x	44	1341	28:1	12°		75		x	x
Nyssoideae															
Nyssa															
Pedicellatae		x	x	Oval-ang.	x		55	1086	20:1	14°			50	x	x
Capitatae		x	x	Oval-ang.		x	112	959	8:1		19°		40	x	x
Generic average		x	x	Oval-ang.		x	83	1022	14:1		17°		45	x	x
Camptotheca acuminata		x	x	Oval-ang.	x		58	894	16:1		25°		25	x	
Sub-family average		x	x	Oval-ang.	x		70	958	15:1		21°		35	x	x
Family average	x	x	x	Oval-ang.	x	x	57	1149	20:1	16°	16°	52	52	x	x

is, of course, possible that their development has been parallel rather than that *N. sylvatica* is derived from, or is only a modified form of *N. sinensis* that has migrated. Let us consider, however, the other generic elements that are in geographic approximation.

N. biflora, which grows in a limited portion of the range of *N. sylvatica*, varies very little anatomically from *N. sylvatica*. Morphologically, the variance is chiefly a matter of possible minor modification. The pistillate flowers are in a group of two rather than three, the leaf is spatulate instead of oval and the ridges of the fruit stone are more pronounced. It is suggested that *N. biflora* was derived very recently from *N. sylvatica* considering the closeness of even the superficial morphological features. *N. ursina*, a shrub growing in a small part of the range of *N. biflora* in Florida, seems to continue trends begun in *N. biflora*.

The small leaves of *N. biflora* have become even smaller, the ellipsoid, sometimes rounded drupes of *N. biflora* have become globular, the pistillate flowers are still two or more in number. Anatomically, *N. ursina* lacks characterization because of inadequate material but the end-wall angle is 16°, higher than either *N. sylvatica* or *N. biflora*. It is suggested that on the basis of the evidence at hand, *N. ursina* seems to be derived from *N. sylvatica* through *N. biflora*. *N. aquatica* seems to diverge from *N. biflora* and *N. ursina* but has qualities in common with *N. sylvatica*. The pistillate flower is borne singly on a long pedicel. The fruit is larger than that of *N. sylvatica* while the fruit of *N. biflora* and *N. ursina* is smaller. They are divergent in many other features. The drupe of *N. aquatica* is purple rather than blue-black and the stone of the fruit is very sharply ridged. Anatomically it is more advanced than the lowest number of the other three species. It has an end-wall angle of 21° as against 11°, 14°, and 16° respectively in the other species. It is suggested then, that *N. aquatica* is derived in a straight line from *N. sylvatica* while *N. biflora* and *N. ursina* developed as an offshoot in the recent geologic past. *N. sylvatica* is isolated from its parent, *N. sinensis* by a climatic and geographic gap.

The nearest relative to *N. javanica*, geographically, is *N. sinensis* from which it varies morphologically only in greater size of parts and the presence of a capitate male inflorescence. Anatomically the variation is in a 8:1 length to width ratio as opposed to a 11:1 ratio in *N. sinensis*, an end-wall angle of 19° as opposed to one of 13° and 48 bars per perforation plate as opposed to 53. These variations are not tremendous but indicate a possible derivation.

What about the relationships between *N. javanica* and the other species which shares the section that Wangerin designated Capitatae? A number of morphological differences between *N. javanica* and *N. ogeche* should be pointed out. There are numerous pistillate flowers in the inflorescence of *N. javanica*, while they are borne singly in *N. ogeche*. *N. ogeche* has an elongate style while that of *N. javanica* is abbreviated. The seed of *N. ogeche* is winged while that of *N. javanica* is hardly ridged. The color of the fruit of *N. ogeche* is red while that of *N. javanica* is dark blue-black. *N. ogeche* has Heterogeneous II B rays while those of *N. javanica* are Heterogeneous II A. *N. ogeche* has 22 fewer bars per perforation plate than *N. javanica*. *N. javanica* has only 5 fewer bars, on the other hand, than *N. sinensis* and is otherwise very close, anatomically and morphologically. It is suggested then, that *N. javanica* is derived from *N. sinensis* as an offshoot of relatively advanced nature and that by evolutionary development has reached a level equal to that of *N. ogeche*.

N. ogeche seems to have been derived from *N. aquatica*. There is no large variation anatomically. The only significant difference is possibly of a derivative nature as *N. ogeche* has Heterogeneous II B rays and 26 bars per perforation plate as opposed to 34 bars in *N. aquatica* whose rays are Heterogeneous II A. The fruit of *N. aquatica* is purple and has sharply ridged stones, while that of *N. ogeche* is red and has winged stones. *N. ogeche* and *N. aquatica* have fruit very close in size and they both develop from pistillate flowers that are solitary, while the leaves of the species are the two largest in the genus. It is suggested,

therefore, that the coincidence of the capitate form of male inflorescence in *N. javanica* and *N. ogeche* does not justify the grouping of the two together as a section, this condition having been independently developed, and that the designation of the sections as such by Wangerin is artificial rather than natural.

Camptotheca, the genus which is considered the most advanced in the family,

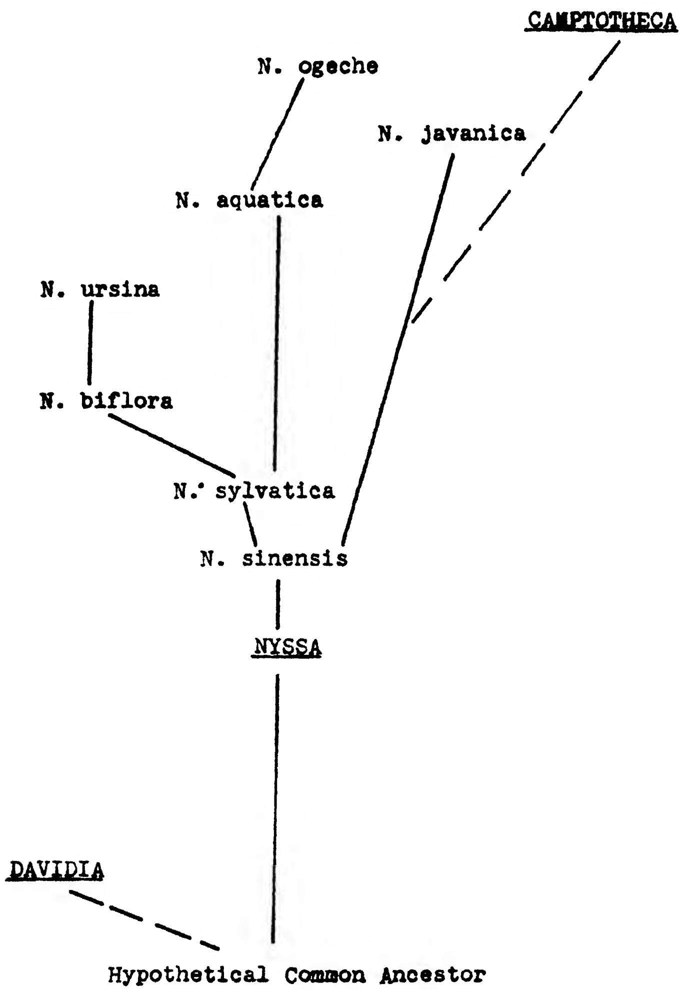

FIG. 1. Suggested phylogenetic relationships in Nyssaceae

has certain qualities intermediate between *N. sinensis* and *N. javanica* and other qualities which are more advanced than either. The leaves of *Camptotheca* are the largest of the entire family, up to 75 cm. in length of blade. The male and female inflorescences are both capitate, an advanced feature. The fruit is in a cluster greater than that of *N. javanica* and becomes dry upon ripening. The anatomy is quite similar to that of *N. sinensis* but varies in having a length to

width ratio greater than that of *N. sinensis* and *N. javanica* (16:1) but a greater end-wall angle (25°), the largest in the family, and also the smallest number of bars per perforation plate, viz. 25. It is therefore suggested that *Camptotheca* arose somewhere on the branch of the phylogenetic line that comes from *N. sinensis* and terminates in *N. javanica*, that it is, perhaps, closer to *N. javanica* in point of origin than to *N. sinensis* and that it has developed to its present high point in geographic proximity to the parent, *N. sinensis*. The other published species, *C. yunnanensis* Dode (1908) appears to be at most a variety since it is described as varying from *C. acuminata* only in having a lighter brown fruit and a slightly variable leaf size. The range is identical with that of *C. acuminata*.

The evidence presented by the present research agrees with the suggestion by Wangerin and others that *Davidia* may be only remotely (if at all) related to the sub-family Nyssoideae. The remoteness of *Davidia*, morphologically and anatomically, is so complete as to make possible the conjecture that development within the family has been polyphyletic. A hypothetical common ancestor of the family as it now stands must have been remote if it existed. It must have been characterized by a height of 40 meters or more, was possibly polygamo-monoecious, with 5–10 stamens in both staminate and pistillate flowers, five sepals and five petals and a racemose inflorescence. The pistil must have been ten-carpellate with an inferior ovary and a drupaceous fruit maturing therefrom with ten seeds with smooth bony coats. Anatomically the ancestor probably possessed medullary rays of Heterogeneous type I, angular vessels with thin and uneven walls, a length to width ratio of 35:1 or more, an end-wall angle of 8° or 9°, and over 75 bars per perforation plate. The side-wall pits must have been scalariform and part elliptic-elongate. Fiber tracheids were present, probably predominant. This common ancestor is remote from the Nyssoidae (see fig. 1).

The relationships, particularly in regard to species, as here presented must be considered as highly speculative. The consideration will achieve completion only after all aspects are examined, particularly those relating to ontogeny of individual species, cytology, and the limits of variability in specific ranges. The fossil record is revealing more and more information and it is hoped that more light will be shed on possible relationships of these genera, both among themselves and exterior to *Nyssaceae*, by future research.

SUMMARY

1. Nyssaceae as a family, shows anatomical features which appear more primitive than the morphological characters.

2. The three genera fall into two groups. The most primitive group consists of *Davidia* and the advanced group consists of *Nyssa* and *Camptotheca* in phylogenetic sequence. This assumption is based on anatomical and morphological evidence.

3. The origin of the family appears to be polyphyletic and possibly far Eastern.

4. The affinity between *Nyssa* and *Camptotheca* is considerably closer than that of either with *Davidia*.

5. Anatomical evidence is in general agreement with the morphological evidence as it relates to the problem of evolution within the family.

ACKNOWLEDGEMENT

I am indeed grateful to Dr. J. E. Adams of the University of North Carolina under whose guidance this research was accomplished. The indebtedness of the writer to the curators of herbaria at the National Herbarium, the New York Botanical Garden, the University of North Carolina, and the Yale School of Forestry for specimens furnished is large.

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AN ANNOTATED LIST OF WASPS FROM NAGS HEAD AND THE KILL DEVIL HILLS

(Hymenoptera Aculeata)

By Karl V. Krombein

Arlington, Virginia

During the period May 23–June 5, 1948 our family stayed at Nags Head, Dare County, North Carolina. This locality is on a narrow sand reef ranging up to about a mile in width and is separated from the mainland by shallow Albemarle Sound. I collected a total of 88 species of wasps during our short stay, almost one-fifth the number of species recorded from the entire state in the State List and Supplement.[1] Of these 88 species, 23 have not been recorded from North Carolina previously, and two genera and one subgenus are also new to the State List. Since the State List includes very meagre coastal records, and since so many of the species I collected were not recorded previously from North Carolina, I considered it worthwhile to prepare the following list.

Collections the first three days were made around Nags Head. The vegetation there is principally sea oats (*Uniola paniculata*) with occasional stands of shrubby bayberry (*Myrica carolinensis*) and *Ilex vomitoria*, and the fauna is correspondingly sparse. The following afternoons through June 2nd (May 29, 31, June 1 and 3 were overcast or stormy with high winds and no collecting was done) collections were made on the low flat area between the dunes and the ocean in the area around Kill Devil Hills. This area, while having a rather barren appearance, supports a diverse vegetation of which the dominant shrubs are *Ilex vomitoria*, bayberry, and live oak (*Quercus virginiana*). West of the dunes is a rather densely wooded area with sandy loam soil which is gradually being encroached upon by the shifting dunes. Collections were made in this environment on June 4th and 5th only, and the list of species would undoubtedly be longer had more time been spent in the woods.

It should be pointed out that the spring of 1948 was a week or two later than normal along the Atlantic Coast. One would normally expect in this latitude to find species of those sand-loving genera, *Oxybelus*, *Bembix*, and *Tachytes*, present by June 1st, but this was not the case in 1948. Collections made during mid-summer probably would more than double the number of species listed here.

The taxonomic arrangement in the following list is that used in the State List to facilitate cross reference, though nomenclatorial changes have been made to conform to usage at present. Genera and species marked with an asterisk have not been recorded from the state previously. I am indebted to H.

[1] "The Insects of North Carolina", by C. S. Brimley, N. C. Dept. Agr. unnumbered publ., 1938, and "Supplement to Insects of North Carolina", by C. S. Brimley, N. C. Dept. Agr. unnumbered publ., 1942.

K. Townes, H. E. Evans, R. M. and G. E. Bohart for confirming or making identifications in several genera as indicated.

Family POMPILIDAE (PSAMMOCHARIDAE of State List)

CEROPALES Latreille

C. bipunctata Say. Kill Devil Hills, 5 ♂♂, May 28–June 4, on sandy barrens around foliage, principally *Salix*.

AGENIELLA Banks

**A. faceta* (Cresson) (det. H. K. Townes). Kill Devil Hills, 1 ♂, June 5, in woods.

DIPOGON Fox (PSEUDAGENIA, in part, of State List)

D. pulchripennis (Cresson). Kill Devil Hills, 1 ♀, May 28, on sandy barrens.

PRIOCNEMIS Schiødte

P. pomilius (Cresson) (= *pompilus* (!) of State List). Nags Head, 1 ♀, May 24. Kill Devil Hills, 32 ♀♀, 15 ♂♂, on sandy barrens.

APORINELLUS Banks[2]

A. fasciatus (Smith). Nags Head, 6 ♀♀, 4 ♂♂, May 23–25. Kill Devil Hills, 4 ♀♀, 2 ♂♂, May 26–June 5, on sandy barrens.

* *A. taeniatus* (Kohl). Nags Head, 3 ♀♀, May 23–25. Kill Devil Hills, 3 ♀♀, May 26–27, on sandy barrens.

PSORTHASPIS Banks (PEDINASPIS of State List)

P. legata (Cresson). Kill Devil Hills, 1 ♂, June 5, in woods.

EPISYRON Schiødte

E. biguttatus (Fabricius). Kill Devil Hills, 1 ♀, June 2, on edge of woods.

E. posterus (Fox). Kill Devil Hills, 2 ♀♀, 1 ♂, June 2–5, on edge of woods and in woods.

E. snowi (Viereck). Kill Devil Hills, 3 ♀♀, May 28–30, on sandy barrens.

SERICOPOMPILUS Ashmead

S. cinctipes (Cresson). Kill Devil Hills, 5 ♀♀, 8 ♂♂, May 27–June 5, the females in the woods, the males on edge of woods or on sandy barrens.

POMPILUS Fabricius (PSAMMOCHARES, in part, of State List)

P. rectus (Banks). Kill Devil Hills, 2 ♀♀, June 5, in woods.

SOPHROPOMPILUS Howard

S. hyacinthinus (Cresson). Nags Head, 1 ♂, May 24. Kill Devil Hills, 15 ♀♀, 3 ♂♂, May 26–June 5, on sandy barrens and edge of woods.

[2] Determinations in this and the following genera of the Pompilidae were confirmed or made by H. E. Evans.

* *S. minusculus* (Banks). Nags Head, 4 ♀♀, 1 ♂, May 24–25. Kill Devil Hills, 4 ♀♀, May 26–30, on sandy barrens.

ANOPLIUS Dufour (PSAMMOCHARES, in part, of State List)

Subgenus LOPHOPOMPILUS Radoszkowski

A. cleora (Banks). Kill Devil Hills, 1 ♀, June 4, on sandy barrens.

A. bengtssoni (Regan). Kill Devil Hills, 4 ♂♂, May 28–June 5, on sandy barrens and in woods.

A. bengtssoni (Regan). Kill Devil Hills, 4 ♂♂, May 28–June 5, on sandy barrens and in woods.

Subgenus NOTIOCHARES Banks

A. philadelphicus (Lepeletier). Kill Devil Hills, 1 ♀, 3 ♂♂, May 26–June 5, on sandy barrens.

Subgenus ARACHNOPHROCTONUS Howard, not Ashmead

(PSAMMOCHARES and POMPILOIDES, in part, of State List)

A. americanus (Beauvois). Kill Devil Hills, 2 ♂♂, May 27–28, on sandy barrens.

A. marginalis (Banks). Kill Devil Hills, 1 ♀, 1 ♂, June 2–4, on sandy barrens.

A. pretiosus (Banks). Kill Devil Hills, 11 ♀♀, 15 ♂♂, May 26–June 5, mostly on sandy barrens, a few on edge of woods.

A. relativus (Fox). Nags Head, 1 ♀, 4 ♂♂, May 24–25. Kill Devil Hills, 14 ♀♀, 20 ♂♂, May 26–June 5, mostly on sandy barrens, a few on edge of woods.

A. semirufus (Cresson). Kill Devil Hills, 3 ♀♀, 1 ♂, June 2–5, mostly in woods, one on edge of woods.

Subgenus ANOPLIUS Dufour

* *A. ventralis* (Banks). Kill Devil Hills, 1 ♀, 1 ♂, May 28, on sandy barrens.

Subgenus POMPILINUS Ashmead (POMPILOIDES, in part, of State List)

A. cylindricus (Cresson). Nags Head, 2 ♀♀, May 24–25. Kill Devil Hills, 10 ♀♀, 1 ♂, May 26–June 5, mostly on sandy barrens, one in woods, and one on edge of woods.

A. marginatus (Say). Kill Devil Hills, 1 ♂, June 5, in woods.

* *A. splendens* (Dreisbach). Kill Devil Hills, 3 ♂♂, May 28–June 5, two on sandy barrens, one in woods.

* *A. subcylindricus* (Banks). Kill Devil Hills, 3 ♀♀, May 26–28, on sandy barrens.

* *A.* n. sp. (to be described by H. E. Evans). Nags Head, 4 ♂♂, May 25. Kill Devil Hills, 20 ♀♀, 12 ♂♂, May 26–June 4, on sandy barrens.

Family RHOPALOSOMATIDAE

* OLIXON Cameron

* *O. banksii* (Brues), new combination, transferred from *Nealgoa*. Kill Devil Hills, 29 ♂♂, May 26–June 5. These interesting brachypterous males were

running swiftly over the sandy barrens. The reasons for the generic transfer and family assignment will be discussed in a separate paper. The species has been taken but rarely, and I know of only five other specimens including the type, all females except one.

Family TIPHIIDAE

TIPHIA Fabricius

* *T. convexa* Allen. Kill Devil Hills, 8 ♀♀, 9 ♂♂, June 4–5, all in woods except one on edge of woods.

T. hollowayi Allen. Kill Devil Hills, 12 ♂♂, June 4–5, on sandy barrens.

* PARATIPHIA Sichel

* *P. algonquina* Viereck. Kill Devil Hills, 1 ♀, 13 ♂♂, June 4–5, on sandy barrens.

Family MUTILLIDAE

PSEUDOMETHOCA Ashmead

P. frigida (Smith) (= *canadensis* of State List). Kill Devil Hills, 2 ♀♀, June 2–5, one in woods, one on edge of woods.

P. sanbornii (Blake). Kill Devil Hills, 2 ♀♀, June 5, in woods.

P. simillima (Smith). Kill Devil Hills, 20 ♀♀, May 26–June 5, mostly on sandy barrens, but some in woods.

P. vanduzeei Bradley. Kill Devil Hills, 1 ♀, June 5, in woods.

DASYMUTILLA Ashmead

D. lepeletierii (Fox). Kill Devil Hills, 1 ♂, June 5, on sandy barrens.

D. mutata (Blake) (= *allardi* of State List). Kill Devil Hills, 2 ♀♀, June 5, in woods.

D. nigripes (Fabricius) (= *sparsa* and *sparsa segregata* of State List). Kill Devil Hills, 4 ♀♀, June 5, in woods.

D. vesta (Cresson). Kill Devil Hills, 1 ♀, June 5, in woods.

TIMULLA Ashmead

T. dubitata dubitata (Smith). Nags Head, 1 ♀, May 24. Kill Devil Hills, 11 ♀♀, May 26–June 5, mostly on sandy barrens, a couple in woods.

T. dubitatiformis Mickel. Kill Devil Hills, 2 ♀♀, May 28, on sandy barrens.

T. ferrugata (Fabricius). Nags Head, 2 ♀♀, May 24. Kill Devil Hills, 12 ♀♀, May 26–June 5, all on sandy barrens, except one in woods.

T. ornatipennis Bradley. Kill Devil Hills, 3 ♀♀, June 2–4, one on sandy barrens, two on edge of woods.

EPHUTA Say

E. sp. Kill Devil Hills, 5 ♀♀, May 27–30, on sandy barrens.

E. sp. Kill Devil Hills, 3 ♀♀, June 5, in woods.

The two species listed above are distinct in sculpture, type of environment preferred, and actions, but since males were not collected I am unable to name them at present.

Family SCOLIIDAE

CAMPSOMERIS Lepeletier

C. plumipes fossulana (Fabricius). Kill Devil Hills, 1 ♀, June 4, in woods.

Family VESPIDAE

Subfamily ZETHINAE

ZETHUS Fabricius

Z. variegatus Saussure. Kill Devil Hills, 2 ♂♂, May 30, on edge of woods.

Subfamily EUMENINAE

MONOBIA Saussure

M. quadridens (Linnaeus). Kill Devil Hills, 1 ♀, 1 ♂, May 27–June 2, on edge of woods. Others seen on edge of woods and in woods.

RYGCHIUM Spinola (ODYNERUS, in part, of State List)

R. foraminatum (Saussure). Kill Devil Hills, 2 ♀♀, May 30–June 5, in woods and on edge of woods.

* *R. manifestum* (Saussure). Kill Devil Hills, 1 ♀, 5 ♂♂, May 28–June 5, mostly on sandy barrens, one on edge of woods.

R. megaera (Lepeletier). Kill Devil Hills, 3 ♀♀, 5 ♂♂, May 27–June 5, mostly on edge of woods or in woods.

STENODYNERUS[3] Saussure (ODYNERUS, in part, of State List)

* *S. ammonia histrionalis* (Saussure). Nags Head, 2 ♂♂, May 24. Kill Devil Hills, 4 ♀♀, 11 ♂♂, May 26–June 4, on sandy barrens.

S. fulvipes (Saussure). Kill Devil Hills, 2 ♂♂, June 5, in woods.

* *S. histrio* (Saussure). Kill Devil Hills, 5 ♀♀, 2 ♂♂, May 30–June 5, females in the woods, males on the edge of the woods.

* *S. lineatifrons* Bohart. Kill Devil Hills, 5 ♀♀, 15 ♂♂, May 26–June 5, on sandy barrens.

S. pedestris (Saussure). Kill Devil Hills, 4 ♀♀, June 2–5, mostly on edge of woods or in woods.

* *S.* n. sp. (to be described by R. M. Bohart). Kill Devil Hills, 4 ♀♀, 2 ♂♂, May 26–June 5, mostly on sandy barrens, two on edge of woods.

LEPTOCHILUS Saussure

* *L. monotylus* Bohart. Kill Devil Hills, 4 ♀♀, 4 ♂♂, June 2–5, on sandy barrens and in woods.

[3] Determinations in this genus were confirmed or made by R. M. Bohart.

Subfamily POLISTINAE

POLISTES Latreille

P. fuscatus fuscatus (Fabricius). Kill Devil Hills, 2 ♀♀, May 26, on sandy barrens.

P. hunteri Bequaert (= *minor* Auctt., of State List). Kill Devil Hills, 1 ♀ May 30, on edge of woods.

P. metricus Say. Kill Devil Hills, 2 ♀♀, May 26–June 2, on sandy barrens and on edge of woods.

Many other individuals of these three species were seen but not taken.

Subfamily VESPINAE

VESPULA Thomson

V. squamosa (Drury). Kill Devil Hills, 1 ♀, June 2, on edge of woods.

Family SPHECIDAE

Subfamily LARRINAE

Tribe Larrini

MOTES Kohl (NOTOGONIDEA of State List)

M. argentata (Beauvois). Kill Devil Hills, 2 ♂♂, May 28–June 2, one on sandy barrens and one on edge of woods.

TACHYSPHEX Kohl

* *T. similis* Rohwer. Nags Head, 1 ♂, May 24. Kill Devil Hills, 7 ♀♀, 6 ♂♂, May 26–June 5, all on sandy barrens except two females in woods.

T. tarsatus (Say). Nags Head, 2 ♀♀, 1 ♂, May 23–25. Kill Devil Hills, 1 ♀, 11 ♂♂, May 26–June 5, on sandy barrens.

T. terminatus (Smith). Nags Head, 11 ♀♀, 9 ♂♂, May 23–25. Kill Devil Hills, 21 ♀♀, 8 ♂♂, May 26–June 5, mostly on sandy barrens, a few on edge of woods.

* *T.* n. sp. (to be described by G. E. Bohart). Nags Head, 3 ♂♂, May 23–24.

* *T.* n. sp. (to be described by G. E. Bohart). Kill Devil Hills, 2 ♀♀, May 27–28, on sandy barrens.

Tribe Dinetini

LYRODA Say

L. subita Say. Kill Devil Hills, 1 ♀, June 5, on sandy barrens.

Subfamily TRYPOXYLONINAE

TRYPOXYLON Latreille

T. rubrocinctum Packard. Kill Devil Hills, 1 ♀, June 5, in woods.

Subfamily SPHECINAE

CHLORION Latreille

Subgenus PALMODES Kohl

C. abdominalis (Cresson). Kill Devil Hills, 1 ♂, June 4, on sandy barrens.

Subgenus PRIONONYX Dahlbom

C. pubidorsum (Costa). Kill Devil Hills, 2 ♀♀, 23 ♂♂, May 26–June 4, on sandy barrens, a few on edge of woods. Extremely common, and many more could have been taken.

Subgenus ISODONTIA Patton

C. auripes Fernald. Kill Devil Hills, 1 ♂, June 2, on edge of woods.
C. aztecum aztecum (Saussure). Kill Devil Hills, 1 ♀, June 5, in woods.

SPHEX Linnaeus

S. procerus (Dahlbom). Kill Devil Hills, 5 ♂♂, May 28–June 5, on sandy barrens and in woods.

SCELIPHRON Klug

S. caementarium (Drury). Nags Head, 1 ♂, May 25.

Subfamily PSENINAE

Tribe **Psenini**

PLUTO Pate (= PSENIA Malloch, preoccupied, of State List)

* ***Pluto arenivagus***, new species

Psenia anguilicornis Malloch, in part, 1933. Proc. U. S. Natl. Mus. **82**, Art. 26: 48 (labeled var. in key), 58; (♀; Tifton, Georgia, paratype only).

This species appears to be most closely related to *tibialis* (Cresson). The male runs in Malloch's key to *tibialis*, but is distinguished without difficulty by the fact that linear tyloides are present on flagellar segments two through ten (complete except for that on tenth), while in *tibialis* these are present only on segments two or three through eight (complete except for that on eighth). The female runs to couplet 24 in Malloch's key, but is distinguished from *brevipetiolata* (Rohwer) and *pallidistigma* (Malloch) by having the occipital and hypostomal carinae contiguous, whereas they are well separated in those two species. The female has much the aspect of a *tibialis* with red on the abdomen, but lacks the prominent tooth laterally on the pronotum.

Type: ♂; Kill Devil Hills, Dare County, North Carolina; May 28, 1948; (K. V. Krombein; on sandy barrens).

Male.—Length 6.7 mm., forewing 3.7 mm. Black; fore and hind femora beneath, mid femur at tip, all tibiae, and apices of abdominal segments very narrowly, reddish; tegulae testaceous; flagellum brownish beneath, paler on three apical segments; apex of pronotal lobe, spot at base of hind tibia, tibial spurs, and all tarsi except last segment, white to creamy. Vestiture silvery,

short, dense and appressed on clypeus, erect and sparse elsewhere on head, erect and moderately dense on thorax, appressed on abdomen.

Head dull; vertex and temples finely striatopunctate; antennal flagellum stout but not clubbed, complete linear tyloides beneath on segments two to nine and a partial one on tenth.

Thorax dull; pronotum crested but lateral angles not dentate; scutum not rugose, with large, rather dense punctures, the interspaces lineolate; scutellum with sparser, slightly smaller punctures; postscutellum very finely and closely punctate; mesopleuron with large, mostly contiguous punctures, where interspaces are present they are lineolate; propodeal sculpture much as in *tibialis*, the enclosure well marked, with irregular reticulations, the areas adjacent to enclosure likewise irregularly reticulate but the mesh smaller.

Abdomen shining, the petiole 0.78 the length of hind femur.

The male paratypes vary in length from 6.7 to 6.9 mm., and agree very well in details of sculpture and coloration.

Allotype: ♀; same data as type but May 27, 1948.

Female.—Length 7.7 mm., forewing 4.1 mm. Similar in color and vestiture to male with the following exceptions: Femora black except at apices beneath; fore and mid tibiae with a creamy stripe on outer surface; apex of first abdominal tergite, all of second and base of third segments, ferruginous; flagellum light brown beneath on apical seven segments.

Sculpture similar to male with the following exceptions: Flagellum clubbed, tyloides absent; petiole of abdomen 0.64 the length of hind femur; pygidial area not twice as long as its greatest width (1.8:1).

The female paratypes vary from 6.4 to 7.0 mm. (the Georgia specimen), the pygidial area is about twice as long as its greatest width, and the third abdominal segment of the Georgia specimen is almost completely ferruginous.

Paratypes: 1♂, 1♀; same data as type, but May 27, 1948 (♂) and May 30, 1948 (♀). 1♂; Nags Head, Dare County, North Carolina; May 24, 1948; (K. V. Krombein). 1 ♀; Tifton, Tift County, Georgia; (Ashmead collection); (labeled *angulicornis* paratype var.).

The type and allotype are placed on loan deposit in the collection of the U. S. National Museum. The remaining paratypes from North Carolina are in my personal collection, and the Tifton, Ga., paratype is in the U. S. National Museum.

Subfamily BEMBICINAE

Tribe **Nyssonini**

ALYSON Jurine

A. melleus Say. Kill Devil Hills, 2 ♀♀, 1♂, May 26–30, on sandy barrens.

GORYTES Latreille

* ***Gorytes* (*Gorytes*) *dorothyae*[4]**, new species

The present form, known only from the male, is a member of a complex of

[4] For my wife.

closely related species including in the east, *simillimus* Smith and *gyponacinus* Rohwer. Superficially it may be separated from those two forms by the more extensive yellow maculations on the head and legs—in *dorothyae* the mandibles are almost entirely yellow except at extreme tip and base (entirely black or with only a small subbasal spot yellow in the other two species), the clypeus is entirely yellow (apical margin black in the other two), no rather broad black band along subantennal suture (almost always present in the other two), mid and hind coxae entirely yellow except narrowly at base (black except occasionally at apex beneath in the other two), and mid and hind trochanters usually yellow beneath (black in other two). In addition, the rugae on the propodeal enclosure usually extend halfway to the apex in *dorothyae* (present only at extreme base in other two species), rather broad tyloides are present on the first to fourth flagellar segments and a linear one on the fifth (narrower ones on the first or second to third and a linear one on the fourth in the other two), the postscutellum is not foveolate at base (base of postscutellum foveolate in the other two), and the metapleural-propodeal suture is foveolate between the upper and lower metapleural pits (foveolate only above the upper metapleural pit in the other two).

Type: ♂; Kill Devil Hills, Dare County, North Carolina; May 30, 1948; (K. V. Krombein; on edge of woods).

Male.—Length 9.2 mm., forewing 7.3 mm. Black, shining; the following bright lemon yellow—palpi, mandible except extreme base and tip, clypeus, front below antennae and a narrow strip along inner eye margin extending from level of antennae halfway to ocelli, scape entirely, pedicel except a small spot above, transverse band on pronotum, pronotal tubercle, small spot posterolaterally on scutum, spot on base of tegula, apical half of scutellum, large spot on upper anterior part of mesopleuron, large lateral spot on propodeum, fore coxa and trochanter beneath at apex, all of mid and hind coxae except extreme base, mid and hind trochanters beneath, fore and mid femora beneath and at apex above, narrower stripe beneath on hind femora shading to reddish anteriorly, fore and mid tibiae, tibial spurs and tarsi entirely, hind tibia beneath, apical bands on tergites one to five, those of first and second the widest, the others progressively narrower, that on first abruptly narrowed in middle, of second slightly narrowed in middle, second sternite with apical band narrow except laterally, and small posterolateral spots on third and fourth sternites; tyloides on first four flagellar segments and hind tarsi beneath, reddish. Wings hyaline, marginal cell infumated.

Interocular distance at base of clypeus slightly less than height of clypeus in center (7.3:7.8) and slightly less than half the interocular distance at level of anterior ocellus (7.3:15); flagellum moderately long, intermediate segments about twice as long as apical width of each, the first four segments more strongly rounded out beneath than in *simillimus*, tyloides on segments one to four broader than in *simillimus*, that on fifth linear.

Thoracic sculpture very similar to *simillimus* with the following exceptions: Base of postscutellum not foveolate; propodeal enclosure with about a dozen longitudinal ridges on basal half; metapleural-propodeal suture foveolate be-

tween upper and lower metapleural pits (this suture foveolate only above upper metapleural pit in *simillimus* and *gyponacinus*).

Details of abdominal punctation much as in *simillimus* except that punctures on second to sixth tergites are of two distinctly different sizes, rather dense fine ones with scattered larger ones (the scattered larger ones on tergites three to six in *simillimus* and *gyponacinus* evanescent, or at least not readily discernible).

Male paratypes vary in length from 7.7 to 9.2 mm. and show the following differences in coloration: There is usually a dark spot on scape above; trochanters and hind femora beneath may occasionally lack yellow; the band on fifth tergite is lacking in one specimen; the band on second sternite is occasionally reduced to small lateral spots, and the spots on third and fourth sternites are lacking in these specimens. There are slight variations in structural characters as follows: Tyloid of first flagellar segment may be present only on apical third of segment; and the ridges on propodeal enclosure may extend only one-third the distance to apex, or as much as two-thirds (in any case they are always better developed than in any *simillimus* or *gyponacinus* I have seen).

Paratypes: 4♂♂; same data as type. 1♂; same data as type, but June 2, 1948. 2 ♂♂; same data as type, but June 5, 1948; collected in woods.

The type is placed on loan deposit in the collection of the U. S. National Museum, and the paratypes are in my personal collection.

PSAMMAECIUS Lepeletier (GORYTES, in part, of State List)

P. nebulosus (Packard). Kill Devil Hills, 1 ♀, 8 ♂♂, May 30–June 5, in woods and on edge of woods.

NYSSON Latreille

N. opulentus Gerstaecker. Kill Devil Hills, 1 ♂, June 5, in woods.

Tribe **Cercerini**

CERCERIS Latreille

C. robertsoni Fox. Kill Devil Hills, 1♀, 1♂, June 5, female in woods, male on sandy barrens.

Tribe **Bembicini**

MICROBEMBEX Patton

M. monodonta (Say). Kill Devil Hills, 2 ♂♂, May 30, on edge of woods. Common later on sandy barrens.

Subfamily CRABRONINAE

Tribe **Crabronini**

CRABRO Fabricius

Subgenus PARANOTHYREUS Kohl (Subgenus THYREOPUS, in part, of State List)

C. hilaris Smith. Kill Devil Hills, 2♀♀, 11 ♂♂, on sandy barrens, most males around scrub oak (*Quercus marilandica*) foliage.

* Subgenus NORUMBEGA Pate

* *C. argus* Packard. Kill Devil Hills, 3 ♀♀, 9 ♂♂, May 30–June 5, in woods, and on sandy barrens around scrub oak foliage.

ECTEMNIUS Dahlbom (Subgenus CRABRO, of State List)

Subgenus HYPOCRABRO Ashmead

E. decemmaculatus (Say). Nags Head, 1 ♀, 3 ♂♂, May 24–28. Kill Devil Hills, 3 ♀♀, 19 ♂♂, May 26–June 5, on sandy barrens. One male is a melanic, having lost most of the pale markings on the body.

* *E. scaber* (Lepeletier and Brullé). Kill Devil Hills, 1 ♀, 1 ♂, May 26–June 5, the female in woods, male on sandy barrens.

A NEW SPECIES OF CALANOID COPEPOD FROM NORTH CAROLINA

By W. H. Sutcliffe, Jr.[1]

Department of Zoology, Duke University and Duke Marine Laboratory, Beaufort, North Carolina

Introduction. In connection with a shrimp survey and other research on the marine resources of North Carolina, plankton tows were made from the survey vessel *Penny* of the North Carolina Institute of Fisheries Research. The copepod described in this paper was collected in a surface tow on April 20, 1949 in shallow water (about 8 fathoms) south southwest of New River Inlet, North Carolina.

Family PONTELLIDAE

Genus ANOMALOCERA Templeton

Anomalocera ornata new species

Types. Holotype, female, U.S.N.M. No. 89602; allotype, male, U.S.N.M. No. 89603; paratypes, 1 male and 3 females, U.S.N.M. No. 89604; locality, Lat 34°22.5′ N, Long 77°22′ W, surface plankton.

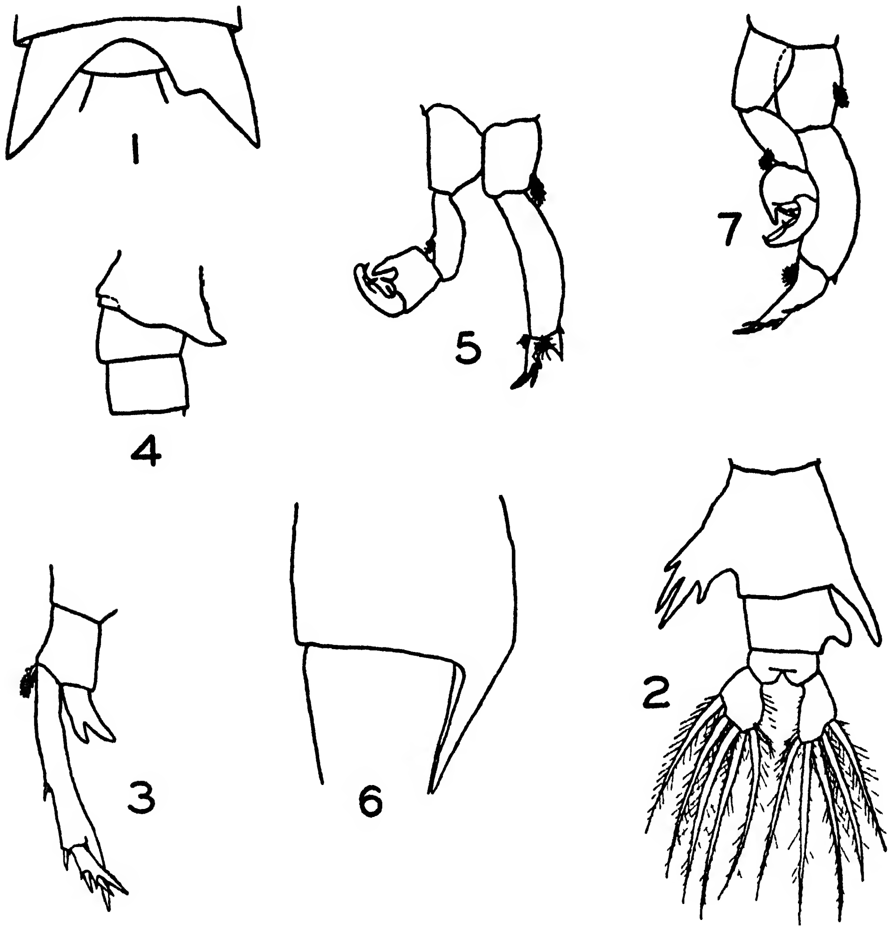
Description. Female: length 4.0–4.4 mm, with the characters of the genus Anomalocera, body form similar to *Anomalocera patersoni* Templeton (1837), corners of fifth thoracic segment produced and medial side of right prolongation with a notch (Fig. 1). Urosome asymmetrical, genital segment with left side produced into a broad process terminating in four pointed projections of which the central two are longest (Fig. 2); right posterior lateral corner of genital segment produced posteriorly and surpassing the following segment, the latter with a posteriorly directed protuberance on right side; caudal furcae only slightly asymmetrical. Fifth legs symmetrical, proximal segment of exopod at most six and a half times as long as wide from its origin to base of second segment, terminal segment armed with two lateral smooth spines and ending in a relatively long-pointed process with a trace of serration on its medial border (Fig. 3).

Male: length 4.2–4.3 mm, general body shape similar to female; ventral eye much more prominent and larger; prolongation of fifth thoracic segment more asymmetrical, right much more produced than left and curved inward and slightly upward; genital segment of urosome produced on right posterior and ending in a point directed almost at right angles to urosome (Fig. 4). Right first antenna forming a grasping organ similar to *Anomalocera patersoni*. Fifth legs asymmetrical (Fig. 5), third segment of left leg bifurcate, medial portion about twice the length of lateral, medial portion terminated in a sharp point and equipped with three spines on lateral side, two setose projections near base

[1] The writer is indebted to Mr. C. E. Atkinson, Director of the U. S. Fish and Wildlife Laboratory at Beaufort, N. C., for bringing the specimens to his attention.

of segment; chela of right leg roughly quadrate and with a short thumb and a long curved finger, the latter with three small spines in its inner edge.

Remarks. The most distinctive characteristic separating *Anomalocera ornata* from *A. patersoni* is the projection from the left side of the genital segment of



FIGS. 1–7. 1. Fifth thoracic segment, female, *Anomalocera ornata*. 2. Urosome, female, *A. ornata*. 3. Fifth leg, female, *A. ornata*. 4. Portion of urosome showing projection from genital segment, male, *A. ornata*. 5. Fifth legs, male, *A. ornata*. 6. Portion of urosome showing genital and following segment, female, *A. patersoni*. 7. Fifth legs, male, *A. patersoni*.

the female; *A. patersoni* lacks any such protuberance (Fig. 6). *A. patersoni* has symmetrical corners on the fifth thoracic segment with respect to the medial notch found on the right side of *A. ornata*. *A. ornata* has only slight serrations on the medial termination of the distal exopod segment of the fifth legs, whereas *A. patersoni* is distinctly toothed. In addition, the proximal exopod segment of the fifth leg is of different proportions in the two species; with *A. ornata* at

most six and a half times as long as wide, with *A. patersoni* eight to eight and a half times as long as wide.

In the male the character of the fifth legs as well as the genital segment will distinguish the two species. The differences of the terminal segment of the left fifth legs as well as the extra spine which *A. ornata* has on the finger of the chela are seen in Figs. 5 and 7. The projection on the right side of the genital segment differs in the two species. In *A. ornata* the projection is more or less broadly triangular with the tip directed nearly at right angles to the urosome (Fig. 4); in *A. patersoni* this projection is long, acuminate, and directed posteriorly.

LITERATURE CITED

Templeton, Robert. 1837. Description of a new Irish crustaceous animal. Trans. Ent. Soc. Lond. 2: 34–40.

STUDIES IN THE COMPOSITAE OF NORTH CAROLINA

II. The Compositae of Wake, Durham, and Orange Counties*

By R. K. Godfrey

Department of Botany, North Carolina State College
Raleigh, North Carolina

INTRODUCTION

This annotated catalogue, with keys, represents an attempt to present a useful local treatment of the Compositae. For students who are attempting to learn the local representatives of a large plant family, the advantages of a treatment of a restricted area are several. For example, it is less cumbersome to use than a manual covering a region which is geographically extensive and physiographically complex, and it gives more definite and tangible data regarding distribution of the taxonomic entities within the area covered.

Small's Manual (1933) is the most recent complete study including the small area under consideration here. Blomquist and Oosting's guide (1948) includes all of the area except the portion of Wake County which is on the coastal plain, but it does not purport to treat the late summer and fall flora. A great many of the composites bloom in the late summer and autumn; many of them are, therefore, not included in it.

The plant names used in this catalogue are those considered to be most generally acceptable under the established rules of botanical nomenclature. Many of them are at variance with the names in Small's Manual. Inasmuch as anyone who uses this treatment will often wish to consult that manual for detailed descriptions and general range data, synonyms are given in the listing of the species wherever practicable. In the few instances where a species or variety is one which has been described since the publication of the Manual, the name, as listed, is preceded by an asterisk and followed by the year of the literature citation in which its original description is to be found.

This study is based primarily upon collections from Wake, Durham, and Orange Counties, North Carolina, which are deposited in the herbaria of North Carolina State College, Duke University, and the University of North Carolina, which institutions are respectively located in those counties as named. Distribution notes are, for the most part, in terms of habitats and are based largely upon the author's field observations rather than upon data as given on herbarium sheet labels. Definite range limits within the area are defined only when there seems to be evidence that a species is restricted in its occurrence to some small portion of it. It is to be expected that other species, particularly in the larger genera, will be found to occur in the area.

* For the first paper in this series, see Godfrey, *Studies in the Compositae of North Carolina*, I. *Liatris*, Jour. Elisha Mitchell Sci. Soc. 64: 241–249. 1948.

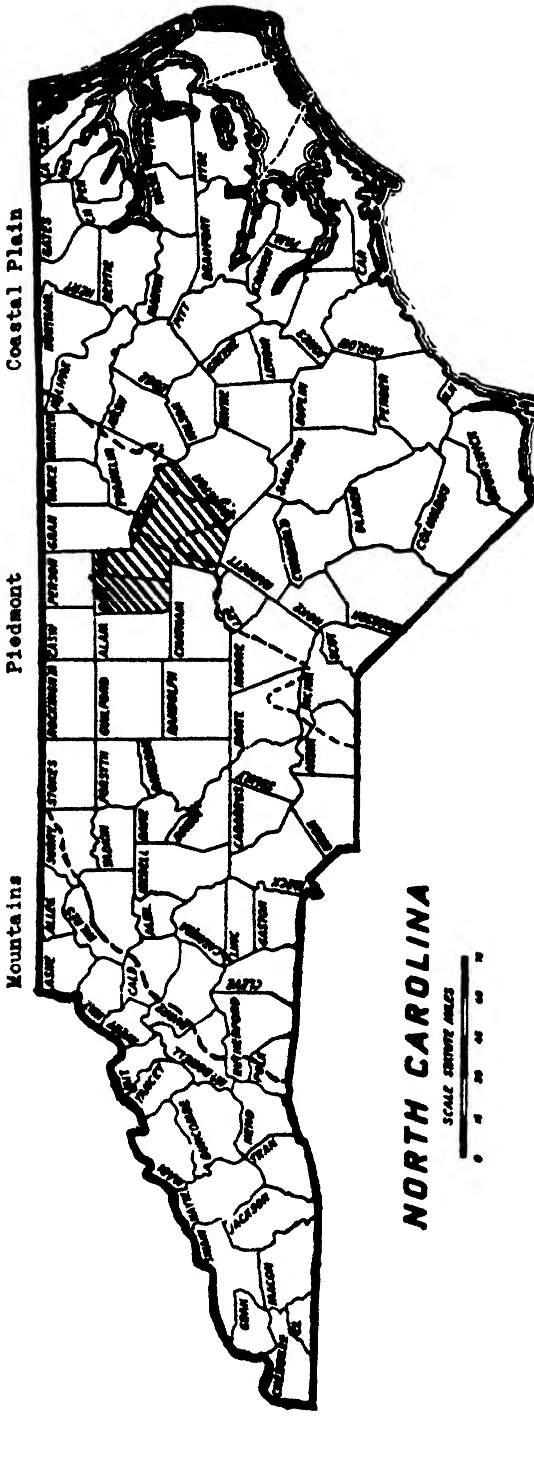


FIG. 1. Outline map showing area covered by this study shaded-in.

An outline county map of North Carolina (Fig. 1) with this three-county area shaded-in is included; it also has the three principal physiographic provinces of the state roughly defined. As can be seen from the map, these three counties are largely on the piedmont, but with a part of Wake County lying on the innermost coastal plain.

ACKNOWLEDGEMENT

I am indebted to the botany staffs at Duke University and at the University of North Carolina for courtesies and privileges extended to me at those institutions during the preparation of this paper. To my colleagues at North Carolina State College who have been helpful, particularly to Professor B. W. Wells and Dr. William B. Fox, I express my sincere appreciation.

KEY TO THE GENERA*

1. All flowers of the head with tubular, radially symmetrical, corollas (heads discoid), or with the marginal flowers definitely ligulate and the inner tubular (heads radiate).
  2. Plants monoecious, staminate and pistillate flowers in separate heads on the same plant.
    3. Phyllaries (involucral bracts) of the staminate heads somewhat united, those of the pistillate heads united and enclosing a single flower, thus when mature simulating an achene .... *Ambrosia* (23)
    3. Phyllaries of the staminate heads distinct, those of the pistillate heads essentially united forming a bur, but free at the tips in the form of hooked spines and enclosing two flowers .... *Xanthium* (24)
  2. Plants dioecious, polygamo-monoecious, or with all bisexual flowers.
    4. Plants dioecious, staminate heads and pistillate heads on different plants.
      5. Shrubs; pappus bristles distinct .... *Baccharis* (14)
      5. Low, woolly herbs, leaves mostly basal, the inflorescence on a scape; pappus bristles united at the base .... *Antennaria* (16)
    4. Plants not dioecious.
      6. Heads discoid (no definitely ligulate corollas although the outer flowers may have larger and more showy, slightly bilateral, tubular corollas than the inner).
        7. Plants having all the flowers in the head bisexual.
          8. Pappus composed of capillary bristles.
            9. Pappus of two series of bristles, the outer minute, the inner much longer .... *Vernonia* (1)
            9. Pappus of a single series of bristles all of the same length.
              10. Heads few-flowered, strict, clustered in glomerules, the glomerules subtended by a few foliaceous bracts .... *Elephantopus* (2)
              10. Heads not few-flowered, not strict, and not clustered in glomerules, but distinctly separate
                11. Receptacles of the heads naked.
                  12. Plants climbing vines with opposite leaves .... *Mikania* (4)
                  12. Plants erect, the leaves variously arranged.

* In this key no attempt has been made to key-out the genera in a "natural" sequence. So-called natural and artificial characters have both been utilized in an attempt to make a key which would not be too technical yet which would facilitate the user's gaining some real concept of the genera.—The number in parentheses following each genus indicates the number of that genus in the sequence of the catalogue that follows.

13. Pappus bristles smooth or scabrous, but not either barbellate (with short divergent setae), or plumose (with long divergent setae).
 14. Pappus bristles smooth and soft; principal phyllaries in a single series, with only a very much reduced series of bracts at the base of the involucre.
  15. Leaves palmately veined and lobed; flowers white.... *Cacalia* (45)
  15. Leaves pinnatifid; flowers yellow.................... *Senecio* (46)
 14. Pappus bristles scabrous; phyllaries progressively unequal and imbricated in several series......................... *Eupatorium* (3)
13. Pappus bristles barbellate or plumose.
 16. Corollas purplish; phyllaries closely imbricated in several series, not striate; perennial herbs with corms or tubers and a spicate, racemose, or racemose-paniculate inflorescence.................. *Liatris* (7)
 16. Corollas whitish; phyllaries few and loosely imbricated, striate-nerved; perennial herbs, but never with corms or tubers, and having a cymose-paniculate inflorescence............................. *Kuhnia* (5)
11. Receptacles of the heads chaffy or bristly.
 17. Pappus bristles scabrous or barbellate; leaves not spiny-toothed.
  18. Pappus bristles scabrous; phyllaries closely imbricated in many series, each ending in a hooked spine......................... *Arctium* (47)
  18. Pappus bristles barbellate; phyllaries imbricated loosely in several series, not ending in hooked spines.... .... *Carphephorus* (6)
 17. Pappus bristles plumose; leaves spiny-toothed... .... *Cirsium* (48)
8. Pappus composed of scales, teeth, or awns.
 19. Phyllaries nearly equal, in 1–2 series; pappus of 5–6 membranaceous, pointed scales; flowers purple to whitish; achenes 5-angled......... *Marshallia* (35)
 19. Phyllaries in an outer foliaceous series and an inner bracteous series; pappus of 2 or 4 teeth or awns; flowers yellow to whitish; achenes flattened or 4-angled *Bidens* (34)
7. Plants polygamo-monoecious, having heads with marginal flowers differing from the inner (the marginal pistillate, either sterile or fertile,* and the inner bisexual, either sterile or fertile).
 20. Receptacles of heads bristly; marginal flowers of the heads sterile.
  21. Heads subtended by foliaceous bracts; leaves spiny-toothed; corollas of the marginal flowers shorter than those of the inner............... *Cnicus* (50)
  21. Heads not subtended by foliaceous bracts; leaves not spiny-toothed; corollas of the marginal flowers much larger and more conspicuous than those of the inner, the heads thus seemingly radiate.................. *Centaurea* (49)
 20. Receptacles of the heads naked; marginal flowers of the heads fertile.
  22. Involucre long-cylindrical, the principal phyllaries in one series, a few much reduced bracts at the base; pappus of copious, soft, white bristles *Erechtites* (44)
  22. Involucre turbinate to hemispheric, the phyllaries closely imbricated in several series; pappus of several comparatively stiff bristles.
   23. Corollas white; phyllaries all scarious although sometimes purplish; plants not emitting a strong camphoric odor; stems and leaves usually woolly-pubescent; receptacles of the heads alveolate; achenes terete or slightly flattened, not ribbed.............................. *Gnaphalium* (17)

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* The fertility of the ray *vs.* the disk flowers can usually be determined even before maturity by an examination and comparison of their ovularies and the exercise of some judgment as to their relative degree of development.

23. Corollas purplish; outer phyllaries herbaceous, the inner scarious, both often purplish; plants emitting a strong, unpleasant, distinctly camphoric odor; stems and leaves not woolly, stems, at least, glandular-puberulent; receptacles of the heads naked; achenes 5-angled.................................*Pluchea* (15)

6. Heads radiate (the marginal flowers with distinctly ligulate corollas (rays), the inner with tubular corollas (disk flowers).
 24. Rays yellow, or dull-rose purple (in one genus only).
  25. Pappus all, or in part at least, of capillary bristles.
   26. Pappus wholly of capillary bristles.
    27. Principal phyllaries all of equal length and in 2 series in a bell-shaped involucre, or in 1 series in a cylindrical involucre with a few much reduced bracteoles at the base.
     28. Leaves opposite, the larger ones basal, the inflorescence essentially scapose; pappus of scabrous capillary bristles; phyllaries in 2 series in a bell-shaped involucre....................*Arnica* (43)
     28. Leaves alternate, cauline; pappus of copious soft capillary bristles; phyllaries in 1 series forming a cylindrical involucre with bracteoles at the base..........................*Senecio* (46)
    27. Phyllaries unequal, imbricated in several series.
     29. Annuals; inflorescence an open panicle (with solitary heads on divergent branches); receptacles of the heads alveolate *Haplopappus* (9)
     29. Perennials; inflorescence of numerous heads crowded in thyrsoid-, racemose-, or racemose-secund panicles; receptacles of the heads naked, not alveolate..............................*Solidago* (10)
   26. Pappus of an outer series of very short small scales and an inner series of capillary bristles...................................*Chrysopsis* (8)
  25. Pappus not even in part of capillary bristles, either crown-like, or of a few scales, or of awns or teeth, or none.
   30. Phyllaries in a single series.
    31. Phyllaries in one series and united except at the very tips so that the involucre is in the form of a tube.......................*Tagetes* (39)
    31. Phyllaries in a single series, but not united.............*Madia* (37)
   30. Phyllaries in more than one series.
    32. Ray flowers fertile, disk flowers sterile.
     33. Achenes not obcompressed, i.e., flattened parallel to the phyllaries.
      34. Achenes partially enclosed by the inner unarmed phyllaries *Polymnia* (18)
      34. Achenes closely surrounded by the prickly inner phyllaries *Acanthospermum* (19)
     33. Achenes obcompressed, i.e., flattened parallel to the phyllaries.
      35. Achenes 4-angled; rays 5–6; low herbs flowering in spring *Chrysogonum* (21)
      35. Achenes winged; rays numerous, tall coarse herbs flowering in summer and autumn.......................*Silphium* (20)
    32. Ray flowers sterile and disk flowers fertile, or both fertile.
     36. Ray flowers sterile and disk flowers fertile.
      37. Stem conspicuously winged; rays irregularly disposed about the margin of the heads......................*Actinomeris* (31)
      37. Stems not winged; rays regularly disposed about the margin of the heads.

38. Rays dull rose-purple; receptacles of the heads conical; chaff longer than the disk flowers . . . . *Brauneria* (29)
38. Rays yellow; receptacles of the heads flat or convex; chaff not longer than the disk flowers.
39. Phyllaries all of the same type and imbricated.
40. Pappus deciduous, composed of 2 thin scales on the angles of the achenes, sometimes with intermediate smaller scales *Helianthus* (30)
40. Pappus none, or a low crown . . . . *Rudbeckia* (28)
39. Phyllaries in two distinct series, the outer foliaceous, the inner nearly membranaceous.
40. Pappus awns barbed . . . . *Bidens* (34)
40. Pappus awns, if present, not barbed . . . . *Coreopsis* (33)
36. Ray flowers and disk flowers both fertile.
41. Pappus of 1–3 awns or teeth . . . . *Verbesina* (32)
41. Pappus none.
42. Phyllaries nearly equal in 2–3 rows; leaves long-petioled . . . *Heliopsis* (25)
42. Phyllaries of 2 series, an outer composed of 4 foliaceous bracts united at the base to form a 4-angled cup, and an inner of smaller chaffy bracts; leaves sessile or connate . . . . *Tetragonotheca* (27)
24. Rays white, or varying from pink to lavender or purple.
43. Pappus of capillary bristles.
44. Corollas of *disk* flowers white or stramineous; rays few, usually 4–6 *Sericocarpus* (13)
44. Corollas of *disk* flowers yellow, red, brown, or purple; rays numerous.
45. Phyllaries nearly equal and scarcely imbricated; receptacles of the heads naked, not alveolate . . . . *Erigeron* (12)
45. Phyllaries unequal and imbricated in several series; receptacles of heads alveolate . . . . *Aster* (11)
43. Pappus of chaffy scales, or a crown, or none.
46. Receptacles of the heads naked . . . . *Chrysanthemum* (42)
46. Receptacles of the heads chaffy.
47. Ray flowers and disk flowers both fertile.
48. Leaves opposite.
49. Phyllaries 10–12 in 2 series; receptacles of the heads flat; leaves sessile, of a lanceolate type . . . . *Eclipta* (26)
49. Phyllaries 4–5; receptacles of the heads conical; leaves petioled, of an ovate type . . . . *Galinsoga* (36)
48. Leaves alternate.
50. Achenes flattened, callous-margined; rays short and broad *Achillea* (40)
50. Achenes terete, ribbed; rays longer than broad . . . . . . *Anthemis* (41)
47. Ray flowers fertile, disk flowers not fertile . . . . *Parthenium* (22)
1. All flowers of the head with ligulate corollas.
51. Pappus composed entirely of capillary bristles.
52. Pappus bristles plumose . . . . *Hypochaeris* (53)
52. Pappus bristles not plumose, smooth, scabrous, or with short barbellate setae.
53. Phyllaries in 1 series of equal bracts . . . . *Crepis* (58)
53. Phyllaries in more than one series.
54. Achenes not flattened, either columnar or fusiform.
55. At maturity, the hypanthium extended beyond the body of the achene in the form of a long beak.

56. Pappus soft-white; heads solitary on a hollow scape *Taraxacum* (54)
56. Pappus reddish, or rust-colored; heads solitary on a branched scape, or on a branched, leafy stem . *Pyrrhopappus* (57)
55. At maturity, the hypanthium not extended beyond the body of the achene in the form of a long beak.
57. Phyllaries in 2 series, long linear ones in an inner row, and short bracteoles at the base; heads nodding *Prenanthes* (59)
57. Phyllaries unequal and imbricated; heads erect *Hieracium* (60)
54. Achenes flattened.
58. Achenes truncate at the apex, not appreciably narrowed from the middle, heads many-flowered, 50 or more flowers in each; heads at maturity swollen at the base *Sonchus* (55)
58. Achenes narrowed at the apex, usually beaked; heads with 30 or fewer flowers in each; heads at maturity not swollen at the base *Lactuca* (56)
51. Pappus of scales, or of scales and bristles.
59. Pappus of a crown of scales; phyllaries in 2 series; rays blue or rose *Cichorium* (51)
59. Pappus of scales and bristles; phyllaries in 1 series; rays yellow or orange *Krigia* (52)

CATALOGUE OF THE SPECIES AND VARIETIES WITH KEYS

1. *Vernonia* Schreb. Ironweed

a. Phyllaries with long filiform tips; pappus purple or purplish; leaves lanceolate to lance-oblong, the blades tapering to both ends 1 *V. novaboracensis*
a. Phyllaries tipped by short awns; pappus stramineous; leaves broadly ovate-lanceolate, abruptly contracted below the middle to a winged petiolar portion 2 *V. glauca*

1. *V. novaboracensis* Willd. Frequent. Low, wet pastures, seepage slopes, and wet thickets. Late summer and autumn.

2. *V. glauca* (L.) Willd. Frequent. Pine woods, dry oak-hickory slopes, dry thickets, and grass-weed borders. Some specimens of this species have phyllaries with filiform tips. To these the name **V. glauca* forma *longiaristata* Fern. (1941) has been given. Late summer and autumn.

2. *Elephantopus* (Vaill.) L. Elephant's Foot

a Leaves mostly cauline and all of the same type 1. *E. carolinianus*
a. Leaves chiefly basal; inflorescence scapose with a few bract-like leaves subtending the inflorescence branches.
b Leaves and stems densely tomentose; longest phyllaries up to 1.4 cm. long; achenes 4–5 mm. long, pappus bristles 7–8 mm. long 2. *E. tomentosus*
b Leaves and stems strigose-puberulent; longest phyllaries not exceeding 8 mm. long; achenes 3 mm. long; pappus bristles 4 mm. long 3. *E. nudatus*

1. *E. carolinianus* Raeuschel. Frequent. Moist cut-over woodlands, stream bank woods, and in weed thickets of disturbed areas. Late summer and autumn.

2. *E. tomentosus* Willd. Frequent. Pine woods, dry-cut-over woodlands, and in pastures. Late summer and autumn.

3. *E. nudatus* A. Gray. A coastal plain plant known in our area from a single

locality in Wake County, a bog at Method just west of Raleigh.* Late summer and autumn.

3. *Eupatorium* (Tourn.) L.

a. Leaves verticillate†; heads purple.
  b. Leaves lanceolate to oval, tapering at the base, pinnately-veined; stem not purple-specked.
    c. Stems hollow, purple, glaucous; leaves in 4's to 6's, with blunt teeth; florets scarcely exserted from the involucre; corolla 3.5–4.8 mm. long 1. *E. fistulosum*
    c. Stems solid, green with purple nodes, faintly glaucous; leaves in 3's to 4's, rarely 2's or 5's, sharply toothed; florets much exserted from the involucre; corollas 5.5–7.5 mm. long 2. *E. purpureum*
  b. Leaves ovate to ovate-lanceolate, abruptly contracted into the petiole, more or less 3-nerved; stem purple-specked 3. *E. dubium*
a. Leaves opposite, or the upper ones alternate (occasionally 3 at a node, but if so the heads not purple); heads white, whitish, or blue or violet
  d. Leaves connate-perfoliate or connate-clasping.
    e. Leaves broad at the bases and connate-perfoliate 4. *E. perfoliatum*
    e. Leaves narrowed at the base and connate-clasping 5. *E. cuneatum*
  d. Leaves not either connate-perfoliate or connate-clasping, either sessile or petioled.
    f. Leaf blades dissected or pinnatifid, the segments filiform 6. *E. capillifolium*
    f. Leaf blades entire, toothed, or incised, but definitely not pinnatifid.
      g. Leaf blades petioled, or only a part of them sessile.
        h. Heads blue or violet 7. *E. coelestinum*
        h. Heads white or whitish.
          i. Phyllaries unequal, the outer much shorter than the inner, and imbricated 8. *E. serotinum*
          i. Phyllaries nearly equal, a few outer ones but little shorter than the inner, and not giving the involucre an imbricated appearance.
            j. Leaves crenate, middle cauline leaves largest and petioled, smaller cauline leaves near the base and the top of the plant and sessile 9. *E. aromaticum*
            j. Leaves serrate; all petioled, the largest at the base of the plant and diminishing in size upward 10. *E. rugosum*
      g. Leaf blades all sessile
        k. Leaves lanceolate, elliptic, or varying to ovate or suborbicular.
          l. Plants glabrous, or pubescent only in the inflorescence; leaves ovate-lanceolate, gradually tapering from the broadly cuneate base to an acute or acuminate tip 11. *E. sessilifolium*
          l. Plants pubescent throughout
            m. Leaves of a lanceolate or elliptic-lanceolate type.

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* See Fox, William B., and R. K. Godfrey, "Notes on Plant Distribution in North Carolina. I." Rhodora **51**: 129–146, for reports of several other coastal plain plants from this locality.

† Key to the three species of purple verticillate *Eupatoria* adapted from Wiegand, Rhodora **22**: 62. 1920.

n. Leaves strongly three-nerved, not conspicuously reticulate-veined between, entire or remotely toothed above the middle; phyllaries obtuse, glandless
12. *E. altissimum*

n. Leaves obscurely three-nerved, conspicuously veined between, coarsely toothed from near the base; phyllaries acute, glandular
13. *E. album*, var. *glandulosum*

m. Leaves of an ovate type.

o. Leaves ovate-lanceolate, much longer than broad, crenate-dentate to coarsely but bluntly toothed; inflorescence branches generally alternate
14. *E. pilosum*

o. Leaves of a broadly ovate type, nearly as broad as long; inflorescence branches generally opposite and numerous, forming a broad compound corymb.

p. Leaf blades having the main lateral veins arising with the midvein at the base of the blade, often all three principal veins running parallel for a short distance............................15. *E. rotundifolium*

p. Leaf blades having the main lateral veins arising from the midvein well above the base of the blade.

q. Leaf blades cuneate or at most sub-truncate at the base
16. *E. pubescens*

q. Leaf blades sub-cordate to broadly truncate at the base
17. *E. cordigerum*

k. Leaves linear-lanceolate to narrowly linear.

r. Phyllaries with attenuate scarious tips; leaves lanceolate to linear-lanceolate, serrate; stem slender, usually simple to the inflorescence....18. *E. leucolepis*

r. Phyllaries with obtuse or rounded tips; leaves narrowly lanceolate to linear or linear-filiform, entire; stem usually much branched.

s. Heads about 5 mm. high; pappus 4 mm. high; leaves narrowly linear to linear-filiform..19. *E. hyssopifolium*

s. Heads about 7 mm. high; pappus 6 mm. high; leaves narrowly lanceolate to oblanceolate, twisted at the base so that the flat surfaces are oriented vertically to the ground......................................20. *E. linearifolium*

1. *E. fistulosum* Barratt.* Frequent. Moist, tall weed thickets, seepage slopes, open stream banks. Late summer and early autumn.

2. *E. purpureum* L. Infrequent. Woods and thickets. Late summer and autumn.

3. *E. dubium* Willd. Confined in our area to the coastal plain portion of Wake County where frequent in similar habitats to *E. fistulosum*. Late summer and autumn.

4. *E. perfoliatum* L. Frequent. Wet pastures, seepage slopes, and along the banks of small streams, either in woods or open fields. Late summer and autumn.

5. *E. cuneatum* Engelm. Included on the basis of a single specimen collected many years ago by Dr. W. C. Coker in Orange County.

6. *E. capillifolium* (Lam.) Small. Frequent. Lowland old fields and pastures. Autumn.

* No attempt is made here to relate the names *E. fistulosum* Barratt, *E. purpureum* L., and *E. dubium* Willd. to names for verticillate *Eupatoria* in Small's Manual. For a discussion of the nomenclature of this group see Wiegand and Weatherby, Rhodora **39**: 297–306. 1937.

7. *E. coelestinum* L. Infrequent. Lowland pastures and moist, open woods. Autumn.

8. *E. serotinum* Michx. Occasional. Moist tall weed thickets, the more moist pine and cut-over woods, or edges of wet woodlands. Late summer and autumn.

9. *E. aromaticum* L. Frequent. Pine, oak-hickory, and cut-over woods. Autumn.

10. *E. rugosum* Houtt. (*E. urticaefolium* Reichard.) Rare. Wet floodplain woodland. In the area known from a single locality in Wake County. The specimen corresponds to *E. rugosum* forma *villicaule* Fern. (See Fernald, Rhodora **44**: 463. 1942).

11. *E. sessilifolium* L. Rare. Open pine woodland. Included on the basis of a single record from Wake County. The specimen corresponds to *E. sessilifolium* var. *Vaseyi* (Porter) Fern. and Grisc. (See Fernald and Griscom, Rhodora **37**: 180. 1935.)

12. *E. altissimum* L. Rare. Roadside grass-weed border. Based on one record from Wake County. Late summer and autumn.

13. *E. album* L., var. *glandulosum* (Michx.) Fern. Frequent. Pine and oak-hickory woods. Late summer and autumn.

14. *E. pilosum* Walt. (*E. verbenaefolium* Michx.) Frequent. Bogs, open pine woods, and grass-weed borders. Late summer and autumn.

15. *E. rotundifolium* L. Frequent. Pine woods, bogs, seepage slopes, and old fields. Late summer and autumn.

16. *E. pubescens* Muhl. Occasional. Dry pine, oak-hickory, and cut-over woods. Late summer and autumn.

17. * *E. cordigerum* Fern. (1945). In the area known only in Wake County where there are several stations for it. Bogs, wet thickets, and moist pockets in pine woods. Late summer and autumn.

18. *E. leucolepis* (DC) T. & G. Known in the area in but one locality in Wake County, the bog at Method just west of Raleigh. Late summer and autumn.

19. *E. hyssopifolium* L. Frequent. Open pine, oak-hickory, and cut-over woods, old fields, and grass-weed borders. Late summer and autumn.

20. *E. linearifolium* Walt. (*E. tortifolium* Chapm.) Confined to the coastal plain portion of Wake County. Sandy old fields, open pine woods, and grass-weed borders. Late summer and autumn.

4. *Mikania* Willd. Climbing Hempweed

M. scandens (L.) Willd. Frequent. Moist tall weed thickets, and borders of wet woods. Late summer and autumn.

5. *Kuhnia* L.

K. eupatorioides L. Infrequent. Open pine woods. Autumn.

6. *Carphephorus* Cass.

C. bellidifolius (Michx.) T. & G. Frequent. Open pine and cut-over woods, and grass-weed borders. Late summer and autumn.

7. *Liatris* Schreb. Blazing Stars

a. Pappus plumose .... 1. *L. squarrosa*
a. Pappus barbellate.
  b. Phyllaries acute to acuminate, the mid-veins distinct and forming a rigid keel
  2. *L. regimontis*
  b. Phyllaries obtuse to broadly rounded, the mid-veins not distinct.
    c. Leaves linear; heads small (not over 1 cm. broad).......... 3. *L. graminifolia*
    c. Leaves lanceolate to oblanceolate or obovate; heads large (about 1.5 cm. broad)
    4. *L. scariosa*, var. *squarrulosa*

1. *L. squarrosa* (L.) Michx. Infrequent. Open pine woods and grass-weed borders. Summer.

2. *L. regimontis* (Small) K. Sch. Gaiser (1946) cites one specimen from Wake County. Late summer and autumn.

3. *L. graminifolia* (Walt.) Willd. Common. Open pine woods, grass-weed borders, and occasional in oak-hickory woods. Late summer and autumn.

4. *L. scariosa* (L.) Willd., var. *squarrulosa* (Michx.) Gray. Infrequent. Grass-weed borders and open woods. Late summer and autumn.

8. *Chrysopsis* Nutt. Golden Aster

a. Leaves narrowly lanceolate or linear, grass-like, the principal veins parallel.*
  b. Plants with prolonged flagelliform or filiform stolons and eventual slender rhizomes.
    c. Involucre pilose to silky-lanate, phyllaries and peduncles not glandular
    1. *C. nervosa* var. *stenolepis*
    c. Involucre not pilose or silky-lanate, phyllaries and peduncles glandular
    2. *C. adenolepis*
  b. Plants cespitose or tufted, the basal offsets erect or at most short and promptly assurgent stolons........................ .... 3. *C. graminifolia*
a. Leaves lanceolate to elliptic-lanceolate or oblanceolate, definitely not grass-like.
  d. Stems simple and erect, or if branched at the base, the branches erect; stems and leaves with a sparse long-villosity; lower cauline leaves much larger than the upper and narrowed to definite winged petioles................ .... 4. *C. mariana*
  d. Stems much branched from a crown, the branches decumbent; stems and leaves rather densely and uniformly white cottony-lanate; lower cauline leaves essentially like the upper and all sessile ... . 5. *C. gossypina*

1. *C. nervosa* (Willd.) Fern., var. *stenolepis* Fern. (*Pityopsis graminifolia* (Michx.) Nutt. *sensu* Small). Rare. Included here on the basis of one specimen cited by Fernald (1942). It was from the coastal plain portion of Wake County at McCullers. Late summer.

2. * *C. adenolepis* Fern. (1942). Rare. Grass-weed borders, open woods. Late summer and autumn.

3. *C. graminifolia* (Michx.) Ell. (*Pityopsis aspera* (Shuttlw.) Small). Frequent. Open pine woods, grass-weed borders, occasionally in oak-hickory woods. Summer and autumn.

* Key to the linear-leaved *Chrysopis* adapted from Fernald in Rhodora **44**: 468. 1942.

4. *C. mariana* (L.) Nutt. Frequent. Pine woods, grass-weed borders, and occasionally in oak-hickory woods. Summer and autumn.

5. *C. gossypina* (Michx.) Nutt. (*C. pilosa* (Walt.) Britton *sensu* Small; includes *C. gossypina*, forma *decumbens* (Chapm.) Godfrey). Confined in the area to sandy ridges in the coastal plain section of Wake County. Late summer and autumn.

9. *Haplopappus* Endl.

H. divaricatus (Nutt.) Gray (*Isopappus divaricatus* (Nutt.) T. & G.). In the area, frequent only in Wake County. Old fields and grass-weed borders. Autumn.

10. *Solidago* L. Goldenrods

a. Leaves narrowly linear to linear-filiform; inflorescence corymbose and more or less flat-topped ....1. *S. microcephala*
a. Leaves not narrowly linear, broader; inflorescence paniculate.
  b. Heads not unilaterally arranged on the inflorescence branches (not secund), inflorescence thyrsiform.
    c. Heads white or cream colored ....2. *S. bicolor*
    c. Heads yellow
      d. Plants having no basal rosettes of leaves.
        e. Plants pubescent throughout; involucre squarrose; median cauline leaves larger than either the lowermost or the uppermost.....3. *S. petiolaris*
        e. Plants glabrous at least below; involucre not squarrose; larger cauline leaves lowermost and gradually diminishing in size upwards.
          f. Plants glabrous throughout; leaves sharply serrate, thin; inflorescence not terminal, the lower clusters of heads in the axils of ordinary cauline leaves ....4. *S. caesia*
          f. Plants glabrous below, hirsutulous in the inflorescence; leaves entire, coriaceous; inflorescence a large terminal thyrse........5. *S. speciosa*
      d. Plants having conspicuous basal rosettes of leaves.
        g. Stems puberulent throughout; phyllaries acute to acuminate..6. *S. puberula*
        g. Stems glabrous below, puberulent in the inflorescence; phyllaries obtuse or rounded at the tips....................7. *S. erecta*
  b. Heads unilaterally arranged on the inflorescence branches (secund), inflorescence a terminal spreading panicle.
    h. Plants not having long, horizontal stolons.
      i. Stems sharply angled; lower cauline leaves mostly about 1.5 dm. long and about 5–7 cm. wide, the blades gradually narrowed into a winged petiole which is decurrent on the stem....................8. *S. salicina*
      i. Stems not sharply angled; lower cauline leaves mostly shorter, if up to 1.5 dm. long then not over 3 cm. wide; petioles if winged, not decurrent.
        j. Leaves all entire and sessile, no basal rosettes of petioled leaves, leaves pellucid-dotted, sweet-scented....................9. *S. odora*
        j. Leaves, some at least, toothed, the lower cauline sometimes narrowed to winged petioles, basal rosettes of petioled leaves present, leaves not pellucid-dotted nor sweet-scented.
          k. Stems ashy-whitish with a short puberulence throughout ....10. *S. nemoralis*
          k. Stems glabrous at least below.

l. Stems glabrous throughout; rosette and lower cauline leaf blades lanceolate to oblanceolate, the upper cauline much reduced, linear-filiform; involucres 4–5 mm. high .... [illegible] *pinetorum*

l. Stems glabrous below, pubescent in the inflorescence; [illegible] leaf blades oval-ovate, abruptly contracted below the middle, [illegible] line gradually reduced, elliptic-lanceolate; involucres [illegible]

m. Achenes 2 mm. long, ribbed, clavate ....12. S. *Boottii*

m. Achenes 3 mm. long, ribbed, fusiform ....13. *S. yadkinensis*

h. Plants with long, horizontal stolons, the plants thus usually occurring in colonies.

n. Leaves more or less plainly 3-ribbed, that is, two of the lateral veins prominent and parallel with the mid-rib.

o. Stems puberulent throughout; leaves entire or only remotely toothed, scabrous above, minutely pubescent over the entire under surfaces 14. *S. altissima*

o. Stems glabrous, often glaucous below; leaves sharply though minutely serrate to entire, scabrous above, hirsutulous on the veins beneath 15. *S. gigantea*

n. Leaves not three-ribbed, prominently pinnately veined, sharply serrate.

p. Stems glabrous below, pubescent on the inflorescence branches; leaves smooth to slightly hispid above, pubescent on the veins below 16. *S. rugosa*, var. *sphagnophila*

p. Stems puberulent throughout; leaves rough above, pubescent over the entire under surfaces.

q. Panicle pyramidal, the branches floriferous throughout, or only the lower branches leafy-bracted below........17. *S. rugosa*, var. *aspera*

q. Panicle lax with few distant and prolonged and divergent branches floriferous above the middle ... . 18. *S. rugosa*, var. *celtidifolia*

1. *S. microcephala* (Greene) Bush. (*S. minor* (Michx.) Fern; *Euthamia minor* (Michx.) Greene). Flat-topped Goldenrod. Common. Broom sedge old fields, open pine woods, and grass-weed borders. Late summer and autumn.

2. *S. bicolor* L. White Goldenrod. Frequent. Open pine woods, cut-over woodlands; occasional in oak-hickory woods; rarely in grass-weed borders. Late summer and autumn.

3. *S. petiolaris* Ait. (*S. Milleriana* Mackenzie). Infrequent. Open pine woods, open oak-hickory woods. Late summer and autumn.

4. *S. caesia* L. Frequent. Oak-hickory or beech maple woods, and stream bank woods. Late summer and autumn.

5. *S. speciosa* Nutt. Infrequent. Grass-weed borders, open pine woods. Autumn.

6. *S. puberula* Nutt. Occasional. Open pine woods and grass-weed borders. Late summer and autumn.

7. *S. erecta* Pursh. Frequent. Open pine woods, cut-over woodlands, and occasional in grass-weed borders. Late summer and autumn.

8. *S. salicina* Ell. Infrequent. Wet woodlands, seepage slopes, and very moist tall weed thickets. Autumn.

9. *S. odora* Ait. Sweet-scented Goldenrod. Frequent. Open pine woods, grass-weed borders; occasional in the broomsedge old fields and open oak-hickory woods. Late summer and early autumn.

10. *S. nemoralis* Ait. Frequent. Broom sedge old fields, open pine woods, and grass-wee[illegible]ers. Late summer and autumn.

11. *S.* [illegible]*um* Small. Frequent. Broom sedge old fields, open pine woods, gra[illegible]s, and occasional in the oak-hickory woods. Summer. This species [illegible]ly misidentified as *S. juncea* Ait. which is generally more northern.

12. *S. Boottii* Hook. Occasional. Cut-over woods, grass-weed borders, and open pine woods. Late summer and autumn.

13. *S. yadkinensis* (Porter) Small. Occasional. Cut-over woods, and open pine woods. Late summer and autumn.

14. *S. altissima* L. (*S. hirsutissima sensu* Small). A dominant tall weed of the old fields; frequent in dry tall weed thickets. Late summer and autumn.

15. *S. gigantea* Ait. (*S. serotina* Retz. *sensu* Small). Frequent. Moist tall weed thickets. Late summer and autumn.

16. *S. rugosa* Mill., var. *sphagnophila* Graves. (*S. altissima sensu* Small is *S. rugosa* Mill.) Frequent. Wet woods, seepage slopes, and moist tall weed thickets. Late summer and autumn.

17. *S. rugosa* Mill., var. *aspera* (Ait.) Fern. Frequent. Tall weed thickets, and open stream bank woods. Late summer and autumn.

18. *S. rugosa* Mill., var. *celtidifolia* (Small) Fern. Frequent. Tall weed thickets, and stream bank woods. Late summer and autumn.

These three varieties of the more northern *S. rugosa* intergrade so that it is frequently difficult to relegate a given specimen definitely to one of the above categories.

11. *Aster* (Tourn.) L.

a. Basal and lower cauline leaf blades cordate or abruptly narrowed at the base of the blades, petioled.
  b. Petioles of basal and lower cauline leaves not at all winged; leaf blades sharply serrate; rays white . . . . . 1. *A. divaricatus*
  b. Petioles of the lowermost leaves fairly distinct, becoming progressively shorter and more winged upward; rays bluish.
    c. Stems puberulent throughout; bases of the petioles expanded and clasping; leaves scabrous above, hirsutulous below, entire or with wavy margins; inflorescence a loose, open panicle . . . . . 2. *A. undulatus*
    c. Stems glabrous below, sparingly pubescent in the inflorescence; petiolar bases not expanded and clasping; leaves pubescent above, glabrate below, serrate; inflorescence a relatively dense panicle with ascending branches . 3. *A. sagittifolius*
a. Basal and lower cauline leaf blades not cordate, gradually narrowed at the bases, sessile or petioled.
  d. Pappus double, of an outer series of short, rigid bristles, and an inner of longer capillary bristles; inflorescence cymose.
    e. Cauline leaves short, all about equal (about 2-4 cm. long), linear-oblong, rigid-coriaceous, prominently 1-nerved, with revolute margins; peduncles with stiff, ascending, subulate bracts grading into the phyllaries of the involucres; inner pappus bristles not thickened at the tips; rays blue . . . . . . 4. *A. linariifolius*
    e. Cauline leaves much larger and broader, lanceolate to ovate or obovate, not coriaceous; peduncles naked; inner pappus bristles with thickened tips; rays white 5. *A. infirmus*

d. Pappus simple, of one series of capillary bristles.

f. Rays blue or violet.

g. Stems tall, virgate; heads in elongate racemes or erect-racemose panicles; leaves silvery-silky on both surfaces........................6. *A. concolor*

g. Stems not tall and virgate; heads in open panicles or in cymes; leaves not silvery-silky.

h. Stems pubescent throughout.

i. Involucre squarrose; lower cauline leaves sessile or blades narrowed into petioles, but not clasping.

j. Leaves all sessile; stems high and diffusely branched forming an open paniculate inflorescence with solitary heads terminating the branches 7. *A. grandiflorus*

j. Lower cauline leaves wing-petioled; stems relatively low and slender, bearing a terminal cyme of short-pedicellate heads.

k. Involucre campanulate to hemispheric; phyllaries glandular-pubescent; rays numerous, three-fourths of an inch long or longer 8. *A. spectabilis*

k. Involucre turbinate; phyllaries glabrous on the backs, ciliate on the margins; rays few (9–12), one-quarter to one-half inch long 9. *A. gracilis*

i. Involucre not squarrose; lower cauline leaves clasping by broad truncate or auriculate bases.

l. Stems coarse, reddish, hispid in lines with short, thick, tubercular-based hairs; leaves truncate-clasping; phyllaries not glandular, only slightly pubescent..............................10. *A. puniceus*

l. Stems slender, puberulent; leaves auriculate-clasping; phyllaries glandular-pubescent..... . . .. 11. *A. patens*

h. Stems glabrous throughout.

m. Phyllaries all appressed erect; lower cauline leaves lanceolate to oblanceolate with the blades narrowed into winged petioles 12. *A. laevis*

m. Phyllaries spreading at the tips; leaves all linear, rigid 13. *A. novi-belgii*, var. *elodes*

f. Rays white (sometimes becoming purplish in older heads).

n. Stems simple, zigzagged; heads in a terminal cyme. . 14. *A. acuminatus*

n. Stems branched, the inflorescence a diffuse panicle, not zigzagged.

o. Inner phyllaries slenderly and sharply pointed, not dilated at the apices, tending to become inrolled at the tips.

p. Stems villous throughout; lower cauline leaves lanceolate or oblanceolate 15. *A. pilosus*

p. Stems glabrous or sparsely villous; lower cauline leaves narrowly lanceolate or linear.........................16. *A. pilosus*, var. *demotus*

o. Inner phyllaries broadly and bluntly pointed, dilated at the apices, not inrolled at the tips.

q. Lower cauline leaves elongate, linear-lanceolate to linear, not tapering much from the middle, rigid-coriaceous and revolute; upper cauline leaves conspicuously reduced, bract-like, and numerous, the heads being borne singly at the ends of ascending or divergent bracteate peduncles..........................17. *A. dumosus*, var. *coridifolius*

q. Lower cauline leaves linear-lanceolate to elliptic or oblanceolate, tapering from a broader middle portion to both ends, not particularly rigid, the cauline leaves gradually diminishing in size upward, and the peduncles of the heads not with many equal bracteate leaves.

r. Cauline leaves linear to linear-lanceolate, only slightly narrowed from the middle to either end . . . . 18. *A. vimineus*

r. Cauline leaves lanceolate to elliptic or oblanceolate, acuminate at both ends.

s. Heads more than 10 mm. broad; disk flowers not purplish; stems essentially glabrous . . . . 19. *A. simplex*

s. Heads less than 10 mm. broad; disk flowers purplish; stems puberulent, becoming glabrate below . . . . . 20. *A. lateriflorus*

1. *A. divaricatus* L. Frequent. Beech-maple and stream bank woods. Autumn.

2. *A. undulatus* L. Frequent. Grass-weed borders, open pine woods, dry cut-over woods, and occasionally in oak-hickory woods. Autumn.

3. *A. sagittifolius* Willd. Infrequent. Tall weed thickets. Autumn.

4. *A. linariifolius* L. (*Ionactis linariifolius* (L.) Greene). Frequent. Grass-weed borders and open pine woods. Autumn.

5. *A. infirmus* Michx. (*Doellingeria infirmus* (Michx.) Greene). Infrequent. Oak-hickory, beech-maple, and stream bank woods. Late summer and autumn.

6. *A. concolor* L. Frequent. Grass-weed borders, open pine woods, broom sedge old fields. Autumn.

7. *A. grandiflorus* L. Frequent. Grass-weed borders, open pine woods, dry cut-over woods. Autumn.

8. *A. spectabilis* Ait. Rare. Collections of this species are from Durham County only. Autumn.

9. *A. gracilis* Nutt. Rare. Known from one station in Durham and one in Wake County. Autumn.

10. *A. puniceus* L. Occasional. Moist tall weed thickets. The plant which occurs in the area is probably identifiable with *A. puniceus* L., var. *firmus* (Nees) T. & G., forma *lucidulus* (Gray) Fernald.* Autumn.

11. *A. patens* Ait. Frequent. Grass-weed borders, open pine woods, dry cut-over woods, and occasional in oak-hickory and stream bank woods. Autumn.

12. *A. laevis* L. Infrequent. Grass-weed borders and open pine woods. Autumn.

13. *A. novi-belgii* L., var. *elodes* (T. & G.) Gray. Infrequent. Moist tall weed thickets. Autumn.

14. *A. acuminatus* Michx. Rare. Based on one collection from Orange County.

15. *A. pilosus* Willd. Frequent. Grass-weed borders and cut-over woodlands. A dominant in the tall weed stage of the old field succession. Autumn.

16. *A. pilosus* Willd., var. *demotus* Blake. (*A. ericoides* of many authors, probably *A. ramosissimus* Mill. in Small.) Frequent. Habitat as for the species, but confined to the more sterile soils. Autumn.

17. *A. dumosus* L., var. *coridifolius* (Michx.) T. & G. Frequent. Grass-weed borders, open pine woods, and occasionally in oak-hickory woods. Autumn. Many plants included here are as described for *A. dumosus*, var. *subulaefolius* T. & G., but the two grade imperceptibly into each other.

* See Fernald in Rhodora **51**: 95. 1949.

18. *A. vimineus* Lam. Occasional. Wet woods, stream bank woods, and moist tall weed thickets. Autumn.

19. *A. simplex* Willd. Occasional. Wet woods, open stream bank clearings. Autumn.

20. *A. lateriflorus* (L.) Britton. Frequent. Wet woods, stream bank woods, moist tall weed thickets, and beech-maple woods. Autumn.

12. *Erigeron* L.

a. Rays inconspicuous, scarcely longer than the pappus; inflorescence an elongate diffuse panicle of very small heads .... 1. *E. canadensis*

a. Rays conspicuous, much exceeding the pappus; inflorescence of a few large heads on slender peduncles, or a cyme of smaller heads.

  b. Perennials; pappus of a single series of bristles.

    c. Principal leaves low on the stem or basal, obovate to broadly spatulate; rays linear, lilac to bluish-purple; heads large (up to 3 cm. broad) and few on a scape 2. *E. pulchellus*

    c. Principal leaves cauline, spatulate; rays very narrow, linear-filiform, roseate to rose-purple; heads smaller (not over 2.5 cm. broad) and several to numerous in a terminal cyme .... 3. *E. philadelphicus*

  b. Annuals or biennials; pappus double, of an outer series of scales and an inner series of deciduous bristles (usually absent in the ray flowers).

    d. Stem pubescent with long, spreading hairs; cauline leaves ovate to oblanceolate, coarsely serrate; phyllaries shallowly serrate or entire; phyllaries with minute pubescence .... 4. *E. annuus*

    d. Stem pubescent with short, appressed-ascending hairs; cauline leaves lanceolate to narrowly oblanceolate or spatulate; shallowly serrate or entire; phyllaries with minute pubescence .... 5. *E. ramosus*

1. *E. canadensis* L. (*Leptilon canadense* (L.) Britton) Horseweed. Frequently dominant in the tall weed stages of the old field succession just following the grass stage and before *Aster pilosus* becomes the dominant. Summer and early autumn.

2. *E. pulchellus* Michx. Robin's Plantain. Occasional. Open stream bank woods, lowland cut-over woodlands, moist open banks, and in open seepage slopes. Spring.

3. *E. philadelphicus* L. Rare. Based on a single collection from Durham County. Spring.

4. *E. annuus* (L.) Pers. Daisy Fleabane or Mayweed. Frequent in the late spring aspect of the old fields the year following cultivation; frequent also in the grass-weed borders. Late spring and early summer.

5. *E. ramosus* (Walt.) B.S.P. White-top. Frequent in similar situations to number 4. Late spring and early summer.

13. *Sericocarpus* Nees. Ragged Asters

a. Stem glabrous throughout; leaves linear .... 1. *S. linifolius*

a. Stem pubescent throughout; leaves broader, obovate, oblanceolate, or elliptic.

  b. Lower cauline leaves from 5–15 cm. long, the blades constricted into winged petioles,

gradually diminishing in size upward, serrate, the upper oblanceolate to elliptic; tips of the outer phyllaries spreading or recurved 2. *S. asteroides*

b. Lower cauline leaves about 2–3 cm. long, obovate, sessile, diminishing little in size upward, entire, the upper short-elliptic; tips of all the phyllaries erect 3. *S. bifoliatus*

1. *S. linifolius* (Walt.) B.S.P. Frequent. Open pine woods and grass-weed borders. Summer.

2. *S. asteroides* (L.) B.S.P. Frequent. Open pine woods, cutover woodlands, and occasional in oak-hickory woods and grass-weed borders. Summer.

3. *S. bifoliatus* (Walt.) Porter. Occasional. Open pine woods and grass-weed borders in the sandy soils of the coastal plain section of Wake County. Autumn.

14. *Baccharis* L. Groundsel Tree

B. halimifolia L. Infrequent. Wet pine woods or in willow-alder thickets. Also naturalized as an escape from cultivation near old homesites in upland areas. Autumn.

15. *Pluchea* Cass. Marsh Fleabanes

a. Leaves, some of them, petioled, broadly elliptic to elliptic-lanceolate, serrate 1. *P. camphorata*

a. Leaves sessile, cordate-clasping, ovate to ovate-lanceolate, denticulate 2. *P. foetida*

1. *P. camphorata* (L.) D. C. (*P. petiolata* Cass. *sensu* authors). Occasional. Wet woods and seepage slopes. Late summer and autumn.

2. *P. foetida* (L.) D. C. Occasional. Seepage slopes and bogs. Late summer and autumn.

16. *Antennaria* Gaertn. Pussy Toes

a Stolons long-filiform, tardily producing rosettes of leaves; heads solitary.* 1. *A. solitaria*

a. Stolons promptly assurgent with leafy tips or rosettes of leaves, heads in corymbs.

b Pistillate involucres 5.7 mm high, mature pappus 4–5 5 mm. long 2. *A. plantaginifolia*

b. Pistillate involucres 7–11 mm high; mature pappus 6–8.5 mm. long.

c. Rosette leaves arachnoid-pubescent above, glabrate when old; stems and involucres not purplish 3. *A. fallax*

c Rosette leaves shiny-glabrous above even when young; stems and involucres purplish . 4 *A. Parlinii* var. *arnoglossa*

1. *A. solitaria* Rydb. Rare. North-facing, wooded stream bluffs. Spring.

2. *A. plantaginifolia* (L.) Richards. Frequent. Dry, sterile grass-weed borders and open pine woods. Spring.

3. *A. fallax* Greene. Frequent. Grass-weed borders and pine woods. Spring.

4. *A. Parlinii* Fern., var. *arnoglossa* (Greene) Fern. Frequent. Grass-weed borders and pine woods. Spring.

* Key to the Antennarias adapted from Fernald, Rhodora 47. 1945.

17. *Gnaphalium* L.

a. Heads in broad panicled cymes; pappus bristles distinct; achenes glabrous.
b. Stem cobwebby or densely woolly-tomentose throughout........1. *G. obtusifolium*
b. Stem glandular-viscid, not woolly-tomentose......2. *G. obtusifolium*, var. *Helleri*
a. Heads in axillary clusters; the inflorescence elongate; pappus bristles united at the base; achenes pubescent.
c. Tomentum on stems and lower leaf surface dense and closely appressed white-cottony, appearing conspicuously silvery to the unaided eye, the tomentum on the upper leaf surfaces much less dense and the surfaces thus appearing somewhat green above; basal and lower cauline leaves thickish, oblanceolate to spatulate; involucres loosely enmeshed in tomentum at their bases, otherwise glabrous, the outer phyllaries short-ovate and scarious, the middle and inner green at the bases, purple-scarious near the middle, and yellow-scarious at the tips, linear-oblong..3. *G. purpureum*
c. Tomentum on stems and both leaf surfaces dense, but less closely appressed, both appearing faintly green through the silvery tomentum; basal and lower cauline leaves spatulate to linear-oblanceolate; involucres essentially glabrous but with some loose tomentum at their bases, the outer phyllaries narrowly ovate, the inner linear-oblong, all essentially yellow-scarious..............4. *G. calviceps*
c. Tomentum on stems and lower leaf surfaces thin and loosely appressed, on the upper leaf surfaces very thin and loose, the plants thus appearing dull-green throughout; basal and lower cauline leaves thinnish, broadly spatulate to obovate; involucres copiously enmeshed in tomentum, the outer phyllaries ovate, tapering gradually to the summits, the middle and inner phyllaries with green centers and scarious margins below and yellow-sacrious tips, broadest at the bases and tapering gradually to the tips ....5. *G. peregrinum*

1. *G. obtusifolium* L. Everlasting. Frequent. Broom sedge old fields, occasional in the tall weed stages of the old fields; frequent in open pine woods and grass-weed borders. Summer and autumn.

2. *G. obtusifolium* L., var. *Helleri* (Britton) Fern. Occasional. Open pine woods and grass-weed borders. Autumn.

3. *G. purpureum* L. Cudweed. Frequent. Sterile, sparsely populated grass-weed borders, and in old fields following cultivation. Spring and summer.

4. *G. calviceps* Fern. Frequent. Occurring in the same situations as *G. purpureum* and the next. Summer.

5. *G. peregrinum* Fern. (*G. spathulatum* of authors) Frequent. Spring and summer.

18. *Polymnia* L.

P. Uvedalia L., var. *floridana* Blake. Frequent. Moist cut-over woodlands, and in moist tall weed thickets. Late summer and early autumn.

19. *Acanthospermum* Schrank

A. australe (Loefl.) Ktze. Spiny Bur. Infrequent as a lawn weed or in dry, sterile grass-weed borders. Late summer.

20. *Silphium* L. Rosin Weeds

a. Plants with stems leafy throughout.
  b. Phyllaries pubescent and with ciliate margins; peduncles densely hispidulose 1. *S. scaberrimum*
  b. Phyllaries not pubescent, but ciliate; peduncles glabrous or sparingly hispidulose 2. *S. astericus*
a. Plants with leaves mostly near the base of the stem, the scapose inflorescence tall, panicled at the summit.
  c. Leaves pedately lobed or divided . 3. *S. compositum*
  c. Leaves coarsely dentate . 4. *S. terebinthinaceum*

1. *S. scaberrimum* Ell. Frequent. Open pine woods, grass-weed borders, and tall weed thickets. Late summer and autumn.

2. *S. astericus* L. Infrequent in similar situations to No. 1.

3. *S. compositum* Michx. Frequent. Open pine woods and grass-weed borders, occasionally in oak-hickory woods. Summer.

4. *S. terebinthinaceum* Jacq. Probably a waif. One collection made along the Seaboard Airline R. R. tracks at Apex, N. C. Summer.

21. *Chrysogonum* L.

C. virginianum L. Golden Star. Frequent. Pine woods, oak-hickory woods, and beech-maple woods; occasional in stream bank woods. Spring.

22. *Parthenium* L. Feverfew

a. Stem glabrous below, puberulent above; cauline leaves sessile, not auricled 1. *P. integrifolium*
a. Stem villous; cauline leaves auriculate-clasping .2. *P. auriculatum*

1. *P. integrifolium* L. Frequent. Open pine woods, grass-weed borders, broom sedge old fields. Spring, summer, and autumn.

2. *P. auriculatum* Britton. Rare. Grass-weed borders. The only collections are from Durham County. Spring and summer.

23. *Ambrosia* (Tourn.) L. Ragweeds

a. Leaves bi- or tripinnatifid . 1. *A. artemisiaefolia* var. *elatior*
a. Leaves not pinnatifid, but some of them deeply three-lobed, serrate.. ...2. *A. trifida*

1. *A. artemisiaefolia* L., var. *elatior* (L.) Descourt. Common ragweed. Frequently a dominant weed in the lowland old fields in the tall weed stage of succession; frequent also as a weed in gardens and around buildings. Late summer and early autumn.

2. *A. trifida* L. Great ragweed. Frequent. Tall weed thickets. Late summer and autumn.

24. *Xanthium* (Tourn.) L. Cocklebur

a. Burs minutely glandular-puberulent or glabrate.. .... .1. *X. chinense*
a. Burs coarsely hispid, especially on the spines .... 2. *X. pennsylvanicum*

1. *X. chinense* Miller. Frequent as a dominant in the lowland old fields· occasional along open stream banks. Late summer and autumn.

2. *X. pennsylvanicum* Wallr. Infrequent. Seepage slopes and wet pastures. Late summer and autumn.

25. *Heliopsis* Pers. Ox-eye

H. helianthoides (L.) Sweet. Frequent. Moist, open pine or oak-hickory woods, and in lowland cut-over woodlands. Summer.

26. *Eclipta* L.

E. alba (L.) Hassk. Occasional. Weed in lowland fields under cultivation; also in the crabgrass stage of the old fields. Summer.

27. *Tetragonotheca* (Dill.) L.

T. helianthoides L. Infrequent. Grass-weed borders and open pine woods. Late spring and early summer.

28. *Rudbeckia* L. Cone-flowers

a. Disk corollas yellow . . . . 1. *R. laciniata*
a. Disk corollas deep purple or black.
  b. Plants very rough and bristly hairy throughout; rays approximately 2–3.5 cm. long; pappus none . . . . 2. *R. hirta*
  b. Plants with spreading hirsute pubescence, but not very rough and bristly; rays approximately 1–1.5 cm. long; pappus a short crown . . . . 3. *R. fulgida*

1. *R. laciniata* L. Goldenglow. Frequent. Tall weed thickets, and in wet woods and stream bank woods. Late summer and autumn.

2. *R. hirta* L. Black-eyed Susan. Infrequent. Grass-weed borders and open pine woods. Summer.

3. *R. fulgida* Ait. Frequent. Moist pine woods and grass-weed borders. Late summer and autumn.

29. *Brauneria* Neck

B. laevigata Boynt. and Beadle. (*Echinacea laevigata* (B. & B.) Small) Purple cone flower. Rare. Grass-weed borders. Early summer.

30. *Helianthus* L. Sunflowers

a. Disk corollas reddish-brown.
  b. Cauline leaves of a lanceolate or linear type, sessile or nearly so
   1. *H. angustifolius*
  b. Cauline leaves of an ovate type, the lower with petioles.
    c. Basal leaf blades ovate or oval, crenate to dentate, blunt, bases abruptly contracted into winged petioles; middle phyllaries broadly rounded to abruptly short-acuminate . . . . 2. *H. atrorubens*
    c. Basal leaf blades ovate to broadly lanceolate, serrate to serrate-dentate, acute, bases gradually tapering into a winged-petiole; middle phyllaries acute
     3. *H. atrorubens*, var. *alsodes*

a. Disk corollas yellow.
  d. Stems smooth below, pubescent in the inflorescence if at all.
    e. Involucres not over 8 mm. broad; stems smooth throughout, not glaucous 4. *H. microcephalus*
    e. Involucres 1 cm. broad or broader; stems glabrous below, usually pubescent in the inflorescence.
      f. Leaf blades broadest at the base, subsessile, divaricate 5. *H. divaricatus*
      f. Leaf blades narrowed at base into winged petioles
        g. Leaves membranaceous, green above and below, sparingly setose above and below; phyllaries linear-lanceolate 6. *H. decapetalus*
        g. Leaves thickish, green and setose above, glaucous below but with setae on the principal veins; phyllaries broadly lanceolate 7. *H. strumosus*
  d. Stems pubescent throughout.
    h. Leaves alternate throughout 8. *H. giganteus*
    h. Leaves opposite on the lower part of the stem at least
      i. Leaves and branches opposite below, becoming alternate in the inflorescence.
        j. Leaves short hirsute beneath; internodes of the inflorescence zigzagging 9. *H. tuberosus*
        j. Leaves tomentose beneath; internodes of the inflorescence not zigzagging 10. *H. tomentosus*
      i. Leaves and branches all opposite 11. *H. hirsutus*

1. *H. angustifolius* L. Occasional. Bogs, meadows, and low, wet, open pine woods. Autumn.

2. *H. atrorubens* L. Frequent. Open pine woods, grass-weed borders, and occasional in oak-hickory woods. Late summer and autumn.

3. *H. atrorubens* L., var. *alsodes* Fern. Occasional. Similar habitats. Late summer and autumn.

4. *H. microcephalus* T. & G. Frequent. Tall weed thickets, edges of woods, and grass-weed borders. Late summer and autumn.

5. *H. divaricatus* L. Frequent. Grass-weed borders, open pine woods and cut-over woods. Summer.

6. *H. decapetalus* L. Frequent. Cut-over woodlands and moist tall weed thickets. Summer and autumn.

7. *H. strumosus* L. Frequent. Cut-over woodlands, open pine woods, and tall weed thickets. Summer and autumn.

8. *H. giganteus* L. Occasional. Tall weed thickets, and wet, open woods. Summer and autumn.

9. *H. tuberosus* L. Frequent. Tall weed thickets and grass-weed borders. Summer and autumn.

10. *H. tomentosus* Michx. Occasional. Lowland, open pine woods and moist tall weed thickets. Summer and autumn.

11. *H. hirsutus* Raf. Occasional. Pine and oak-hickory woods. Summer.

31. *Actinomeris* Nutt.

A. alternifolia (L.) DC. (*Ridan alternifolia* (L.) Britton). Stick weed. Occasional. Tall weed thickets, wooded stream bluffs. Summer and autumn.

32. *Verbesina* L.

V. occidentalis (L.) Walt. (*Phaethusa occidentalis* (L.) Small) Crownbeard. Frequent. Tall weed thickets, cut-over woodlands, lowland pastures and stream banks. Summer and autumn.

33. *Coreopsis* L. Tickseeds

a. Disk flowers red .... 1. *C. falcata*
a. Disk flowers yellow.
  b. Leaves all divided into filiform segments .... 2. *C. verticillata*
  b. Leaves entire or divided, but segments never filiform.
    c. Leaves, all sessile, each leaf divided into three entire, elliptic-lanceolate leaflets, the two opposite leaves, therefore, appearing like a whorl of six; plants erect 3. *C. major*, var. *stellata*
    c. Leaves, the lower at least, petioled, entire or pedately divided; plants low and spreading; lower leaves ovate, ovate-lanceolate, or rarely obovate, often with basal lobes or divisions .... 4. *C. auriculata*

1. *C. falcata* Boynt. Occasional. Bogs, and wet ditches. Late spring or early summer.

2. *C. verticillata* L. Frequent. Open pine woods, grass-weed borders, and cut-over woods. Summer.

3. *C. major* Walt., var. *stellata* (Nutt.) Robinson. Frequent. Sandy, open pine woods, and grass-weed borders; occasional in cut-over woodlands. Summer.

4. *C. auriculata* L. Frequent. Lowland pine woods, oak-hickory and beech-maple woods. Spring.

Several of the cultivated species of *Coreopsis* may be found locally abundant in grass-weed borders along roadsides and in the vicinity of dwellings. No attempt has been made to include them here.

34. *Bidens* L. Beggar Ticks

a. Leaves 1-3 pinnately parted or divided, the divisions not forming definite leaflets; achenes much exserted beyond the tips of the phyllaries; achenes very unequal in size 1. *B. bipinnata*
a. Leaves entire or pinnately compound; achenes about equaling the inner phyllaries; achenes about equal in size.
  b. Leaves simple .... 2. *B. connata* var. *petiolata*
  b. Leaves pinnately compound.
    c. Rays conspicuous, much exceeding the disk .... 3. *B. aristosa*
    c. Rays absent, or little if any exceeding the disk and inconspicuous.
      d. Heads small, about 5 mm. high; awns of the achene 1-2 mm. long, upwardly barbed; rays none .... 4. *B. discoidea*
      d. Heads larger, 1 cm. or more high; awns of the achenes 3-5.5 mm. long, retrorsely barbed; rays present.
        e. Outer foliaceous phyllaries 10-16, much exceeding the disk; rays yellow; achenes dark brown or blackish; setae on the achene margins retrorse 5. *B. vulgata*
        e. Outer foliaceous phyllaries 6-8, little exceeding the disk; rays orange; achenes olive green; setae on the achene margins erect .... 6. *B. frondosa*

1. *B. bipinnata* L. Spanish needles. Frequent as a weed in gardens and around buildings, in moist thickets, pastures, and on brook banks. Summer and autumn.

2. *B. connata* Muhl., var. *petiolata* (Nutt.) Farwell. Occasional. Brook banks, swamp clearings, wet pastures and thickets. Summer and autumn.

3. *B. aristosa* (Michx.) Britton. Frequent. Grass-weed borders. Autumn.

4. *B. discoidea* (T. & G.) Britton. Frequent. Wet woods, moist grass-weed borders and pastures. Summer and autumn.

5. *B. vulgata* Greene. Frequent. Habitat as in No. 4. Summer and autumn.

6. *B. frondosa* L. Frequent. Habitat as in No. 4. Summer and autumn.

35. *Marshallia* Schreb.

M. obovata (Walt.) Beadle and Boynt., var. *platyphylla* (Curtis) Beadle & Boynt. Frequent. Open pine woods and grass-weed borders. Spring and early summer.

36. *Galinsoga* R. & P.

G. ciliata (Raf.) Blake. Richweed. Occasional. Garden weed in very fertile soil. Summer and autumn.

37. *Madia*

Madia sativa Molina. Tarweed. Rare, perhaps a waif. Known in the area from Durham County only. Summer.

38. *Helenium* L. Sneezeweed

a. Leaves linear-filiform, not decurrent on the stem . . 1. *H. tenuifolium*
a. Leaves broader, lanceolate to elliptic or oblanceolate, decurrent on the stem.
  b. Stem simple or little branched with one or only a few heads on long peduncles; principal leaves oblanceolate with wavy margins 2. *H. Curtisii*
  b. Stem much branched with many heads on relatively short peduncles; leaves elliptic, lanceolate, or oblanceolate, serrate to sub-entire 3. *H. autumnale*, var. *parviflorum*

1. *H. tenuifolium* Nutt. Frequent. Grass-weed borders, pastures, and around farm buildings. Late summer and autumn.

2. *H. Curtisii* A. Gray. Occasional. Bogs. Early summer.

3. *H. autumnale* L. var. *parviflorum* (Nutt.) Fern. Occasional. Moist tall weed thickets, wet woodlands, and seepage slopes. Late summer and autumn.

39. *Tagetes* L. Marigold

T. minuta L. Frequent. As a weed in gardens and occasionally in fields. Autumn.

40. *Achillea* (Vaill.) L.

A. millefolium L. Yarrow, Milfoil. Frequent. Grass-weed borders, old fields, open stream banks, and in pastures. Late spring and summer.

41. *Anthemis* (Michx.) L.

a. Plants pubescent; leaves 1–2 pinnately parted into linear or lanceolate, acute lobes; pappus a minute border.......... ....1. *A. arvensis*
a. Plants essentially glabrous; leaves 1–3 pinnately dissected into narrowly filiform, acute lobes; pappus none...2. *A. Cotula*

1. *A. arvensis* L. Corn Camomile. Frequent. Grass-weed borders, and in fields the year following tilling. Spring and early summer.

2. *A. Cotula* L. (*Maruta Cotula* (L.) DC.) Mayweed. Frequent. Grass-weed borders, pastures, and in fields the year following tilling. Spring and early summer.

42. *Chrysanthemum* (Tourn.) L. Ox-eye daisy

C. leucanthemum L., var. *pinnatifidum* Lecoq and Lamotte. Frequent in fields the year following cultivation; frequent also in other stages of the old field succession and in grass-weed borders. Late spring and early summer.

43. *Arnica* L.

A. acaulis (Walt.) B.S.P. Frequent. Open pine woods, wet pastures, and occasional in grass-weed borders. Early summer.

44. *Erechtites* Raf. Fireweed

E. hieracifolia (L.) Raf. Frequent. Cut-over woodlands and weed borders, particularly where fire has occurred. Late summer and autumn.

45. *Cacalia* L. Indian Plantain

C. atriplicifolia L. (*Mesadenia atriplicifolia* (L.) Raf.) Frequent. Moist, tall weed thickets, particularly in cut-over woodlands; occasional also in pine woods, grass-weed borders, and oak-hickory woods. Late summer.

46. *Senecio* (Tourn.) L.

a. Ray flowers absent; leaves all pinnatifid; plant annual.. . ...1. *S. vulgaris*
a. Ray flowers present; some of the basal and lower cauline leaves not pinnatifid, ovate-cordate, or lanceolate to oblanceolate, crenate-serrate, gradually becoming pinnatifid upward.
  b. Basal leaf blades ovate-cordate.. ....2. *S. aureus*
  b. Basal leaf blades oblong to broadly elliptic-lanceolate, or lanceolate to oblanceolate, narrowed at the base, not cordate.
    c. Basal leaf blades oblong to broadly elliptic-lanceolate or lanceolate; plants floccose-tomentose throughout when young, leaves and stems becoming glabrate above, the lower leaf surfaces remaining somewhat tomentose even in age 3. *S. tomentosus*
    c. Basal leaf blades lanceolate to oblanceolate; stems floccose-tomentose only near the bases, the leaves glabrous above.
      d. Heads 1 cm. high, 6–7 mm. broad at the bases of the involucres; rays ca. 1 cm. long; achenes essentially glabrous........4. *S. pauperculus*, var. *praelongus*
      d. Heads not over 8 mm. high, less than 5 mm. broad at the bases of the involucres; rays ca. 6 mm. long; achenes copiously pubescent......5. *S. Smallii*

1. *S. vulgaris* L. Groundsel. Occasional as a weed in fields and around buildings. Winter and spring.

2. *S. aureus* L. Infrequent. Wet, springy woods and meadows. Spring.

3. *S. tomentosus* Michx. Rare in the area, the only known station being in Wake County, sphagnous meadow. Spring.

4. *S. pauperculus* Michx., var. *praelongus* (Greenm.) House. Rare. The only station known for this plant is in Durham County, edge of woods along the old Oxford Road, where Dr. Blomquist discovered it in April, 1949.

5. *S. Smallii* Britton. Frequent. Broom sedge old fields, grass-weed borders, and open pine woods. Spring.

47. *Arctium* L.

A. minus Bernh. Burdock. Rare. Around gardens and buildings. Late summer.

48. *Cirsium* (Tourn.) Hill. Thistles

a. Heads subtended by foliaceous, spinescent bracts . . . 1. *C. spinossimum*
a. Heads not subtended by foliaceous, spinescent bracts.
  b. Phyllaries not spine-tipped . . . 2. *C. muticum*
  b. Phyllaries, the outer at least, spine-tipped.
    c. Plants low and decumbent, spiny tips of the phyllaries appressed-erect . . . 3. *C. repandum*
    c. Plants erect; spiny tips of the phyllaries spreading.
      d. Heads on leafy branches, short pedunculate; leaf margins flat.
        e. Leaves all 1–2 pinnatifid, broadly lanceolate or oblong, decurrent; inner phyllaries as well as the outer, spine-tipped . . . 4. *C. vulgare*
        e. Leaves merely toothed or sparingly sinuate-lobed, a few sometimes pinnatifid, elliptic, not decurrent; inner phyllaries with soft, flat tips . . . 5. *C. altissimum*
      d. Heads terminating long, bracted peduncles; leaf margins revolute . . . 6. *C. revolutum*

1. *C. spinosissimum* (L.) Scop. (*C. spinosissimum* (Walt.) Scop. of authors) Yellow thistle. Frequent. Grass-weed borders, open pine woods, and occasionally in the broom sedge old fields. Spring. There is a form of this species with purple corollas which is locally abundant in the piedmont of North Carolina, but I have not seen it in the area.

2. *C. muticum* Michx. Swamp thistle. Occasional. Lowland pine woods, wet woods, and moist tall weed thickets. Summer and autumn.

3. *C. repandum* Michx. Frequent in open pine woods, grass-weed borders, and old fields in the sandy soils of the coastal plain section of Wake County; rare elsewhere in the area. Summer and autumn.

4. *C. vulgare* (Savi) Airy-Shaw. (*C. lanceolatum* (L.) Hill. of authors). Bull thistle. Frequent. Open pine woods, grass-weed borders, and pastures. Summer.

5. *C. altissimum* (L.) Spreng. Tall thistle. Infrequent. Open woods. Summer.

6. *C. revolutum* Small (*C. virginianum* (L.) Michx., forma *revolutum* (Small) Fern.). Infrequent. Moist, open pine woods and bogs. Summer.

49. *Centaurea* L. Corn Flower

C. Cyanus L. Frequent. Grass-weed borders, and as a weed in clover and grain fields. Spring.

50. *Cnicus* L. Blessed Thistle

C. benedictus L. Occasional in fields the year following cultivation, and in lawns and grass-weed borders. Spring.

51. *Cichorium* (Tourn.) L. Chicory

C. Intybus L. Occasional in the tall weed old fields and grass-weed borders. Summer.

52. *Krigia* Schreb. Dwarf Dandelions

a. Pappus of 5-short, roundish scales, and 5–10 bristles ....1. *K. virginica*
a. Pappus of 10–15 linear-oblong scales, and 15–20 bristles..............2. *K. dandelion*

1. *K. virginica* (L.) Willd. Frequent in fields the year following cultivation; also in lawns, pastures, and sterile grass-weed borders. Spring.
2. *K. dandelion* (L.) Nutt. Frequent. Meadows, pastures, grass-weed borders, and fields following cultivation. Spring.

53. *Hypochaeris* L. Cat's Ear

H. radicata L. Occasional. Grass-weed borders, and in old fields the year after cultivation. Spring and early summer.

54. *Taraxacum* (Haller) Ludwig. Dandelions

a. Achenes olive-green; leaves pinnatifid, the lobes usually not runcinate; involucre not glaucous; phyllaries with no callosity on the back.... .. 1. *T. palustre*, var. *vulgare*
a. Achenes reddish; leaves runcinate-pinnatifid; involucre glaucous; phyllaries with a callosity on the back near the summit....... .... 2. *T. laevigatum*

1. *T. palustre* (Lyons) Lam. & DC., var. *vulgare* (Lam.) Fern. (*T. officinale* Weber; *Leontodon Taraxacum* L.). Frequent as a weed in lawns, pastures, and roadsides. Spring.
2. *T. laevigatum* (Willd.) DC. (*T. erythrospermum* Andrz.; *Leontodon erythrospermum* (Andrz.) Britt.) Frequent in similar habitats to No. 1. Spring.

55. *Sonchus* (Tourn.) L. Sow Thistles

a. Leaf auricles acute; achenes wrinkled and striate......................1. *S. oleraceus*
a. Leaf auricles rounded; achenes not wrinkled, 3-ribbed....................2. *S. asper*

1. *S. oleraceus* L. Infrequent as a weed in gardens, fields, and grass-weed borders. Spring.
2. *S. asper* (L.) Hill. Frequent in habitats as for No. 1. Spring.

56. *Lactuca* (Tourn.) L. Wild Lettuces

a. Achenes with distinct, long-filiform beaks.
  b. Heads 6–12-flowered; leaf margins spiny-toothed .... 1. *L. scariola*
  b. Heads 12–20-flowered; leaf margins not spiny-toothed.
    c. Leaves oblanceolate or obovate, sometimes with small shallow lobes but definitely not pinnatifid, margins entire to denticulate.
      d. Stems glabrous except sometimes at the base; leaves glabrous 2. *L. canadensis*, var. *obovata*
      d. Stems villous into the inflorescence; leaves villous on the midribs 3. *L. canadensis*, var. *obovata*, forma *Steelei*
    c. Leaves in outline linear, lanceolate, ovate-lanceolate, or oblong, entire to pinnatifid.
      e. Leaves sagittate-clasping, ovate-lanceolate to oblong, rays yellowish or cream-colored.
        f. Lower leaves oblong, pinnatifid, with ovate or obovate runcinate lobes; upper leaves lanceolate, not lobed.... 4. *L. canadensis*, var. *latifolia*
        f. Lower and upper leaves all ovate-lanceolate, entire to denticulate, the lowermost sometimes with very shallow dentate lobes 5. *L. canadensis*, var. *integrifolia*
      e. Leaves not sagittate-clasping, the lower pinnatifid, the blades with narrow central portion from which arise linear-runcinate lobes, the upper elongate linear; rays blue, sometimes fading to whitish........ 6. *L. graminifolia*
a. Achenes not filiform-beaked, truncate or with a short, thick beak.
  g. Achenes truncate, not at all beaked; leaves ovate to oblong-lanceolate, rarely runcinate-lobed.................................... 7. *L. villosa*
  g. Achenes with a short, thick beak; leaves all lyrate, or the blades lyrate in outline but with runcinate lobes at the bases................ 8. *L. floridana*

1. *L. scariola* L. Prickly Lettuce. Frequent in grass-weed borders, around farm buildings in weedy places, and occasional in tall weed old fields. Some plants have pinnatifid leaves; others do not. Summer.

2. *L. canadensis* L., var. *obovata* Wieg. Occasional in old fields, grass-weed borders, tall weed thickets, and cut-over woodlands. Summer.

3. *L. canadensis*, var. *obovata*, forma *Steelei* (Britton) Fernald. Occasional along with the variety.

4. *L. canadensis*, var. *latifolia* O. Kuntze. Frequent in tall weed thickets, grass-weed borders, and cut-over woodlands; occasional in the tall weed old fields. Summer.

5. *L. canadensis*, var. *integrifolia* (Bigelow) Gray. (*L. sagittifolia* Ell.). Occasional in grass-weed borders, old fields, and cut-over woodlands. Summer.

6. *L. graminifolia* Michx. Infrequent in dry oak-hickory woods, and grass-weed borders. Spring and summer.

7. *L. villosa* Jacq. Infrequent in stream-bank woods, other moist woods. Late summer and autumn.

8. *L. floridana* (L.) Gaertn. Occasional in tall weed thickets, lowland cut-over woods, and stream bank woods. Late summer and autumn.

57. *Pyrrhopappus* DC. False Dandelion

P. carolinianus (Walt.) DC. Frequent in meadows, grass-weed borders, weedy places around buildings, and occasional in the old fields. Spring and summer.

58. *Crepis* L. Hawksbeard

Crepis pulchra L. Infrequent. Grass-weed borders. Late spring and early summer.

59. *Prenanthes* (Vaill.) L.

a. Involucre of 5 elongate inner phyllaries which equal or slightly exceed the pappus; heads very narrow, not over 3 mm. wide .... 1. *P. altissima*
a. Involucre of 6–8 elongate inner phyllaries which do not equal the pappus, the pappus thus exserted; heads broader, 5 mm. broad or more .... 2. *P. serpentaria*

1. *P. altissima* L. Frequent. Oak-hickory woods; occasional in moist, cut-over woodlands and in pine woods. Autumn.
2. *P. serpentaria* Pursh. Frequent. Open pine woods, cut-over woods; occasional in tall weed thickets. Late summer and autumn.

60. *Hieracium* (Tourn.) L. Hawkweeds

a. Principal leaves basal.
  b. Leaves characteristically purplish or with purple veins; scapes and phyllaries usually purplish, glabrous or very sparingly glandular-pubescent ...... 1. *H. venosum*
  b. Leaves and scapes not purplish; scapes and phyllaries copiously glandular-pubescent.
    c. Mature achenes narrowed at the summit; pubescence of the scapes and phyllaries cinereous; heads numerous on relatively tall, open, cymose panicles or elongate racemose panicles; plants not stoloniferous.................... 2. *H. Gronovii*
    c. Mature achenes not narrowed from the middle to the summit; pubescence of the scapes and phyllaries black; heads solitary or few on low, naked scapes; plants with elongate, leafy stolons .... 3. *H. pilosella*
a. Principal leaves cauline.
  d. Mature achenes narrowed at the summit; leaves obovate, obtuse or broadly rounded at the apices, the lowermost gradually narrowed to winged petioles, pubescent at least below, often shaggy pubescent on the stem and on the leaf margins; peduncles glandular pubescent .... 2. *H. Gronovii*
  d. Mature achenes not narrowed from the middle to the summit; leaves lanceolate to elliptic or oblanceolate, acute or acuminate at the apices, narrowed to the sessile bases, glabrous; peduncles glabrous .... 4. *H. paniculatum*

1. *H. venosum* L. Rattlesnake weed. Frequent. Various types of woods, and grass-weed borders at margins of woods. Spring.
2. *H. Gronovii* L. Frequent. Dry, open woods, cut-over woods, and grass-weed borders. Many of our plants are leafy-stemmed, and have elongate, racemose panicles of heads. These are probably *H. Gronovii*, var. *foliosum* Michx., but the species is so variable and one extreme grades into the other to such an extent that I hesitate to apply names to the extremes. Summer.
3. *H. pilosella* L. Rare. Open woods and banks. Spring and early summer.
4. *H. paniculatum* L. Rare. Oak-hickory woods. Summer and autumn.

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ORIGINAL TREELESS AREAS IN WEST VIRGINIA

By Earl L. Core

Department of Biology, West Virginia University, Morgantown, West Virginia

The statement is generally made that the original vegetation of the middle Appalachian region consisted of some type of forest cover. It is well known, however, that thousands of acres of this area were treeless at the time of the first exploration by European colonists.

George Washington, in his Journal (Toner, 1892), refers to Old Fields and Wild Meadows, and the editor, Toner, gives the following explanation: "There were many small, timberless tracts of land on the mountains and in the great valleys of Virginia and Pennsylvania, in regions which were generally, prior to the occupation and the clearing of the country by the white man, densely covered with trees. Large tracts of such timberless land existed in the region now embraced within the counties of Berkeley, Jefferson and Frederick . . . In some respects these openings resembled the treeless prairies of the west. No satisfactory explanation of this frequently observed condition has ever been given. Many of these meadows were the favorite pasturing grounds of the large game and were . . . of special interest to hunters. Clearfield County, Pa., it is believed, got its name . . . [from] natural clear fields and meadows."

The investigation of these areas and the presentation of a satisfactory explanation of their original treeless condition is necessarily a difficult task at this late time, in view of the universally disturbed conditions, whereby even the precise location of many of the areas is now in doubt. Several possible explanations are here set forth and evidence from observed and recorded facts is advanced to provide what seems to be a satisfactory account.

1. *These areas may correspond to alpine meadows or tundra known to exist above timber line in many parts of the world.*

It is well known, however, that the Southern Appalachians do not afford elevations sufficient for the development of this type of vegetation. Timber line in the Rocky Mountains at the latitude of West Virginia is at approximately 10,000 feet above sea level. Spruce Knob, the highest point in West Virginia, is only 4860 feet above sea level. Furthermore, the original treeless areas, while found almost entirely within the mountain counties, were by no means confined to the higher elevations; as a matter of fact, most of them occur in mountain valleys.

2. *The areas may be of the same origin as the grass balds of the Southern Appalachians.*

Wells (1937) describes 23 *grass balds* of the southern Blue Ridge and the Great Smoky Mountains. Most of these, he states, are on gentle south slopes of rounded ridge tops or gaps near high bold springs. The explanation of these balds has been an enigma to naturalists for centuries. Wells proposed the theory that their

apparent artificial nature points towards their development as fields about Indian camp sites, where mountain grasses, particularly *Danthonia compressa*, obtained such a firm establishment as to be able to compete successfully against woody plants. Wells cites numerous facts in substantiation of this theory, particularly the location of the balds on gentle warm southern slopes near springs. Such descriptions are not applicable to original treeless areas in West Virginia and it may be assumed that Wells' theory, whether satisfactory or not for the balds, has no bearing on the present situation.

3. *The areas may represent heath scrub such as is developed on extremely acid soil in many parts of the world.*

The *heath balds* of North Carolina and Tennessee, in the same region as the grass balds, have also provoked much discussion on the part of botanists (Cain, 1930). Farther north, in the Alleghenies of West Virginia, there are areas which have some features in common with these balds. These Allegheny areas are locally called *huckleberry plains*. Numerous flat-topped mountain ranges above 4000 feet in elevation are covered with a type of vegetation dominated by ericads, particularly species of *Gaylussacia* and *Vaccinium* which are locally of some economic value to mountain folk. Thousands of acres of uninhabited, rolling, treeless barrens are swept by winds often of terrific force, explaining the name Roaring Plains, applied to the largest such area. Scarcely any evidence of a possible earlier forest cover is to be found and it is easy to form the conjecture that the vegetation for centuries has been similar to that existing at present. It has been shown, however, that there is historical proof that the region was once covered with a fine forest which has been destroyed by repeated fires (Core, 1939).

4. *The areas may have represented relict prairies such as are known from Ohio.*

Transeau's classic studies (1935) of the "Prairie Peninsula" are well known, and his location of the eastern boundaries through soil studies, floristic studies, historical records and the like, have reached a high degree of accuracy. While some of the prairie species are represented in the flora of the Alleghenies, the treeless areas of West Virginia have no more than superficial resemblance to prairie lands. The soil types characteristic of climax grasslands, for example, do not occur in the grassy areas of the Alleghenies, nor do the floristic lists coincide. Regardless of the theories that may be accepted to account for the eastward extension of prairies, there seems no reason to doubt the general accuracy of Transeau's map, which represents the eastern outliers at about central Ohio.

5. *The areas may have been fields cleared and cultivated by the aborigines, on which successional processes of a secondary nature were under way.*

There is abundant evidence that at least a few of the areas may be so explained. Early white explorers told of the primitive agriculture practised by the Indians and a few cleared fields existed in the neighborhood of their villages. Warner's map (1738) mentions "Shawno, Indian Fields". Mayo (1737) refers to "Old Fields", and "Shawno Indian Fields". Frye and Jefferson (1751) mention "Shawno Fields".

Kercheval (1833) identifies "Indian Old Fields" as follows: "On the Wappatomaka [The South Branch of the Potomac River], a few miles below the forks, tradition relates that there was a very considerable Indian settlement on the farm of Isaac Vanmeter, Esq. On this water course in the County of Hardy, when the county was first discovered, there was [sic] considerable openings of the land, or natural prairies, which are called the 'Indian old fields' to this day. Numerous Indian graves are to be seen in the neighborhood". A post office, Old Fields, exists at this point.

Butcher (1912) has the following definition: " 'Old Fields' is a common expression for land that has been cultivated by the Indians and left fallow, which is generally overrun with what they call 'broom grass' ".

These areas were doubtless very numerous, although small in size. In addition to the Old Fields post office, mentioned above, there is an Old Field Branch in Greenbrier County, an Old Field Fork in Lewis County and another in Pocahontas County, an Old Field Mountain in Greenbrier County and an Old Field Ridge in Pocahontas County. There seems no reason to doubt the explanation of their origin, as related by the early settlers. Nevertheless, they were very temporary and in a few years would doubtless have become forested again, unless maintained as cleared fields by the white successors to the original cultivators. They by no means account for the many areas where the treeless condition was apparently natural and of indefinite duration. It becomes necessary to look further for an explanation of these.

6. *The areas may be regarded as natural grasslands representing a vegetational type which may be called a glade.*

The term *glade*, according to the Century Dictionary and Cyclopedia was not found in middle English or Anglo-Saxon, but is derived from the Middle English word *glad*, smooth, bright, joyful, derived from the Anglo-Saxon glaed, shining, bright, cheerful (the origin of modern *glad*). In its original sense it was "a smooth bare place or perhaps a bright, light, clear place, as in a wood" (cf. Spenser's Faerie Queene, VI. iv. 13). The *Dictionary of American English* defines glade as "a natural or artificial opening or clearing in a forest." A tract of low swampy land, sometimes inundated and often overgrown with grass; an everglade". It may now be profitable to examine some of the early accounts of the Appalachian glades.

The *Blackwater Chronicle* (Kennedy, 1853), an account of a visit to the Blackwater River section, in Tucker County, has numerous references to glades in the then trackless forests: p. 89: "We at length descended into a beautiful little glade—more properly a dale in the mountains—some two hundred yards wide and two or three miles long"; p. 90: "rode on down the middle of the wild meadow, through green grass, knee-high, and waving gently in the summer wind, until we reached a small stream, whose banks were overgrown with osiers and other delicate shrubs"; p. 102: "winding through the long grass by a track made by the deer" . . . p. 118: "We came to the head of a glade, through which a stream of some size ran and threw ourselves down upon the soft, beautiful grass, knee-high everywhere around".

A Visit to the Virginian Canaan (Strother), written in 1857, has several references to the same region: p. 25: "After a march of six miles they entered a green glade of great beauty, watered by an amber rivulet, which they leaped with their packs and guns. . . . About five o'clock in the afternoon they emerged from the dreary forest into another waving glade, and at the farther border Thornhill gave the welcome order to halt for the night. . . . The horses, relieved of their burdens, were tethered in the glade, up to their bellies in grass".

In the autobiography of the famous hunter Meshach Browning (c. 1859), *glades* are mentioned in about 25 passages, of which the following are representative: p. 102: "proposed removing to the Glades, where we would be sure of plenty of grass for our stock"; p. 104: "proposed to walk a little through the beautiful glade, which was covered with grass knee high, and intermixed with wild flowers of all the kinds and colors that nature had ever produced; p. 361 et seq.: "The glades are, or then were, clear, level meadows, covered with high grass, which was altogether different from what is there produced now, being of a much better character, growing nearly as high as rye, with a blue tassel at the top. The blades were set very thick on the stalk, to the height of three or four feet [doubtless *Calamagrostis canadensis*]. I have often seen that grass tied in a knot over a horse's withers while his rider was sitting on him; and when it was cut in good season, it wintered cattle equally as well as timothy. There were then hundreds, if not thousands, of acres of this grass growing where there is now nothing but bushes, and a rough and very inferior kind of grass. . . . It was a grand sight to watch the tall grass, rolling in beautiful waves with every breeze which passed over its smooth surface, as well as the herds of deer. . . . The glades . . . are large, level bodies of lands, a part of which are open, natural, wild meadows, with a wet, marshy soil".

From these accounts it is readily apparent that the original glades were wet areas and it may be assumed that they represented poorly drained mountain valleys where the vegetation could be classified as a grass-sedge meadow, or *fen*, being a successional stage in the development of the climax deciduous forest characteristic of the region.

Certain areas are still more poorly drained and are characterized, not by a covering of tall grass, but by a mat of sphagnum, in which both the large and small cranberry may be found. These areas may be designated ecologically as *cranberry glades*, since their structure does not resemble exactly the bogs or muskegs (see Scott, 1949) of the North, to which they have been compared. The most famous of these areas is Cranberry Glades (Darlington, 1943), a 600-acre tract in Pocahontas County, but innumerable smaller cranberry glades occur in many places throughout the mountain counties. These areas are covered with peat, varying in thickness from a few inches to 10 feet or more. Acidity is usually very high. Most of the areas are partially covered with sphagnum, with such low seed plants as *Drosera*, *Menyanthes*, and numerous sedges, in addition to the cranberries.

It may be concluded, therefore, that the original treeless areas in the middle Appalachian region represented a relatively small number of "old fields" per-

sisting temporarily from Indian agriculture, but to a much greater extent intermediate stages of succession in the development of the climax association.

In the preparation of this paper, the writer has been greatly aided by use of the book, *West Virginia Place Names, their Origin and Meaning, Including the Nomenclature of the Streams and Mountains*, by Hamill Kenny, published in 1945 by The Place Names Press, Piedmont, West Virginia.

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METHODS FOR STUDYING THE INFLUENCE OF SOCIO-ECONOMIC FACTORS ON THE GROWTH OF SCHOOL CHILDREN—BODY MEASUREMENTS

By A. Hughes Bryan

Department of Public Health Nutrition, University of North Carolina Chapel Hill, North Carolina

AND

B. G. Greenberg

Institute of Statistics, University of North Carolina Raleigh, North Carolina

The material presented in this paper represents the first step in a continuing investigation to test the hypothesis that the body measurements of children of school age can be used to study the level of nutrition of population groups. It is reasonable to believe that this might be so since the classical method in experimental nutrition has been the study of the growth in weight of young rats fed on diets being investigated. The use of measurements of height, weight, and other body dimensions as indices of the nutritional status of school children is, of course, not new. Our contribution is in the application of the statistical method of covariance to the problem of testing the significance of differences in the mean measurements of small groups of children drawn from varying socio-economic backgrounds. As will be seen below, this method permits heights and weights to be adjusted for age, and weights to be adjusted for both height and age, thus facilitating a comparison and analysis of the mean measurements of groups of children.

Previous reports in the literature demonstrating that the more privileged classes have taller, heavier children have been reviewed by Meredith (1941), and will not be detailed here. For the most part, reliance in published studies has been placed upon large samples of children of like age, and large differences in group means, rather than upon smaller samples of children of unequal age in which the variation introduced by age has been removed by statistical methods. The latter procedure is, however, most useful since it then becomes unnecessary to assemble such large groups of families homogeneous in their socio-economic backgrounds or diet patterns in order to obtain significant comparisons. It should be noted that in the area in which we are doing field studies, 1,000 families might be expected to furnish only 45 nine-year old boys. With the method we use, heights and weights can be adjusted for age, and it becomes possible to compare the mean measurements of groups of children whose ages vary over a three to five year span, thus reducing the number of families which must be sampled.

The diet patterns of human population groups are conditioned by a number of

socio-environmental factors, including folkways, education, home food production, income level, food costs, distribution and marketing of food, and facilities in the home for storing and preparing food. We believe that it is very likely indeed that the observed differences in mean heights and weights of groups of children from varying socio-economic backgrounds are due in part to inequal

TABLE 1

Observed and adjusted group mean measurements

	NUMBER OF CHILDREN	OBSERVED GROUP MEANS: Age	OBSERVED GROUP MEANS: Height	OBSERVED GROUP MEANS: Weight	MEAN HEIGHTS ADJUSTED FOR AGE*	MEAN WEIGHTS ADJUSTED FOR AGE*	MEAN WEIGHTS ADJUSTED FOR AGE and HEIGHT*
		mo.	*cm.*	*lbs.*	*cm.*	*lbs.*	*lbs.*
BOYS 108–167 months of age							
Private school urban	25	133.7	147.5	94.6	150.3 ± 1.28	99.4 ± 3.13	91.5 ± 2.51
Rural owner	48	142.2	145.2	80.5	144.8 ± 0.90	79.8 ± 2.19	80.7 ± 1.67
Rural tenant	35	146.3	145.6	81.3	143.7 ± 1.07	78.0 ± 2.62	80.7 ± 2.01
Rural nonagriculture	29	139.7	143.5	79.7	144.1 ± 1.15	80.6 ± 2.82	82.7 ± 2.16
Experiment means		141.2	145.4				
Significance of differences between group means					$P < .01$	$P < .01$	$P < .01$
GIRLS 108–155 months of age							
Private school urban	17	130.9	145.1	83.5	147.9 ± 1.65	87.3 ± 3.39	82.5 ± 2.54
Rural owner	35	138.3	146.7	77.8	146.4 ± 1.11	77.3 ± 2.30	74.7 ± 1.71
Rural tenant	42	139.0	143.4	77.5	142.8 ± 1.02	76.6 ± 2.10	79.1 ± 1.57
Rural nonagriculture	36	137.9	143.5	77.7	143.3 ± 1.10	77.5 ± 2.26	79.1 ± 1.67
Experiment means		137.5	144.5				
Significance of differences between group means					$P = .02$	$P = .06$	$P = .05$

* In the case of boys, the means were adjusted for age 141.2 months, and for height 145.4 centimeters.

In the case of girls, the means were adjusted for age 137.5 months, and for height 144.5 centimeters.

levels of nutritional adequacy dependent upon different dietary patterns. Further work will be needed to establish the validity of this hypothesis.

METHODS

For the purpose of this study of methodology, measurements were made of the heights and weights of a number of rural school children who had attained their ninth birthday and not yet attained their fourteenth birthday. Over this age span the regression of height and weight on age is approximately linear. These rural children, numbering 112 boys and 113 girls, were divided into three groups according to the occupations of their parents: those whose families

were farm owners, those whose families were farm tenants, and a residual group whose families were not engaged exclusively in agriculture. In addition and for contrast, a fourth group was studied consisting of 25 boys and 17 girls from a private school in an urban area. The four groups of children measured were chosen for a study in methodology and are not to be regarded as typical samples either of private school children or of rural children living in this area.

The statistical method used in analyzing the data of this study was the method of covariance (Snedecor, 1946), and the results of the analysis are presented in the tables.

TABLE 2

Adjusted group mean measurements, differences, and their significance
Private school urban group vs. rural group

	Adjusted group means		Difference between means	t and significance
	Private school	Rural		
BOYS 108–167 months of age (private 25, rural 112)*				
Height adjusted for age 141.2 mo., cm.	150 3	144 3	6.0	$t = 4.32$ $P < .01$
Weight adjusted for age 141.2 mo., lbs	99 4	79 4	20.0	$t = 5.71$ $P < .01$
Weight adjusted for age 141 2 mo., height 145.4 cm., lbs.	91.5	81.2	10.3	$t = 3.57$ $P < .01$
GIRLS 108–155 months of age (private 17, rural 113)*				
Height adjusted for age 137.5 mo., cm	147.9	144.1	3.8	$t = 2.11$ $P = .04$
Weight adjusted for age 137.5 mo , lbs.	87.3	77.1	10.2	$t = 2.79$ $P < .01$
Weight adjusted for age 137.5 mo , height 144.5 cm., lbs.	82.5	77.7	4.8	$t = 1.78$ N.S.

* Number of children in groups.

RESULTS AND DISCUSSION

As will be noted from Table 1 the observed mean heights and weights of the eight groups of children were adjusted for age, and in addition the mean weights were adjusted for both age and height, utilizing for this purpose the mean age and the mean height of all boys and all girls studied. Fiducial limits were calculated for these adjusted means and the significance of the differences among the adjusted group means was determined.

Table 2 presents the adjusted group mean measurements of the private school urban boys and girls as compared with those of all three rural groups, together with tests of significance of the differences between these mean measurements.

This table demonstrates that in these particular samples of children, in the case of the boys the mean height adjusted for age of the private school boys was 6 centimeters greater than the adjusted mean height of the boys of the three rural groups. Group mean weights adjusted for age showed that the private school boys were 20 pounds heavier than the rural boys, and when weight was adjusted for both age and height (a process which removes the increase in weight due to height as well as age) the private school boys were 10 pounds heavier than the rural boys. The tests of significance (last column, Table 2) show that when the effect of age is discounted the private school boys were significantly taller and heavier than the rural boys, and when the effect of height as well as age is discounted the private school boys are still significantly heavier than the rural boys.

Turning to the comparison of adjusted mean measurements in private school and rural girls (Table 2) we find less striking differences than was the case with the boys. When the effect of age is discounted the private school girls average 3.8 centimeters taller and 10.2 pounds heavier than the rural girls, and the significance of these differences is indicated in the table. When weights are adjusted for both height and age the private school girls are 4.8 pounds heavier than the rural girls, a difference which has not been shown to be significant in the samples here employed. The possibility of a significant difference might be investigated further using larger samples. It is interesting to speculate why the girls showed less striking differences than the boys between private school and rural groups in adjusted mean heights and weights.

A similar analysis was made of the differences in the adjusted mean measurements of the rural owner boys and girls as compared with the rural tenant boys and girls. The small differences found in adjusted means were not significant except in the case of the one comparison in the girls of heights adjusted for age where the rural owner girls were 3.6 centimeters taller than the rural tenant girls ($t = 2.38$, $P = .03$).

SUMMARY AND CONCLUSIONS

This study indicates that covariance can be applied to the analysis of differences in mean measurements of height, weight, and presumably other body dimensions of small groups of school children from varying socio-economic backgrounds. It is an efficient and appropriate tool for this purpose. In further studies we will seek to confirm and extend this concept of methodology, as well as to determine with other techniques the extent to which these differences in body size can be attributed to differences in dietary pattern and nutritional status.

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A NEW GROUP OF ORGANISMS RELATED TO ACTINOMYCES

By J. N. Couch

Department of Botany, University of North Carolina
Chapel Hill, North Carolina

One of the characteristics of the Actinomycetales is the absence of motile flagellated cells. By using the technics which are commonly employed in isolating the saprophytic Chytridiales, more than a dozen forms have been found and isolated in pure culture, which clearly belong in the Actinomycetales, but produce zoosporangia and zoospores. These organisms appeared in dishes which were baited in the usual way for water molds and chytrids, and their discovery was purely an accident.

Each bit of soil, about a gram or less, was put in a sterile Petri dish, and after half filling each dish with sterile charcoal water, bait in the form of cooked half hemp seeds, small pieces of boiled *Paspalum* grass, and filter paper was added. After a few days the larger water molds and chytrids appeared on the bait, but instead of discarding the old dishes containing the soil, new bait was added from time to time. On February 13, 1948, in examining a piece of filter paper which had been in one of the dishes for several weeks an unusual type of organism was observed consisting of minute globose to subglobose bodies attached to the filter paper fibers by short delicate stalks. These spheroidal bodies formed as a rule in enormous quantities in shallow cultures at the surface of the water, and resembling minute grains of sand had been passed over as agglomerations of bacteria or minute sand grains, until on the above date it was noticed that they were attached to delicate threads, and gave rise to zoospores in zoosporangia. Since this first type was found in soil from the Philippine Islands a total of eleven other isolations and purifications have been made from soil from various locations.

These forms grow very slowly. In water cultures on grass leaves a well developed growth, visible with a lens, appears after ten days or two weeks. In soil dilutions in Jensen's dextrose casein agar these new forms appear after eight to twelve days as tiny spheres a millimeter or less in diameter, while typical *Streptomyces* has attained a growth of at least a centimeter.

The mycelium on boiled *Paspalum* grass leaves is richly branched and very delicate. All the forms or species now in culture turn the leaves in water cultures reddish or pinkish. One of the species, when grown on pieces of boiled *Paspalum* grass leaves in water, forms short, twisted aerial hyphae visible under the microscope, but none has been found so far which forms the abundant tufts of aerial mycelium or the beautiful, symmetrically coiled aerial hyphae of certain species of *Streptomyces*.

These new forms have now been cultured on most of the usual agar media used for *Streptomyces*, as Czapek's solution agar with and without glycerine,

Krainsky's dextrose asparagin, calcium malate, dextrose casein, nutrient agar for bacteria, potato dextrose agar, Drechsler's agar for *Actinomyces*, etc., and on gelatin, and produce the same types of growth on agar and gelatin as have been described particularly by Jensen (1930–31) for the genus *Micromonospora*. On certain agars these new forms produce a very remarkable and characteristic growth with a smooth, convoluted or nodulose, wet, slimy surface instead of the floccose surface characteristics of most species of *Streptomyces*. Some species on certain agars form a tough, cartilaginous surface growth. A thin radial section, through the growth of collection number P15 from surface to the bottom of the dish, shows that the tough cartilaginous surface growth is composed of a dense layer of vertical hyphae between which are interlaced scattered, horizontal hyphae, while below this dense layer are loosely arranged threads which extend for the most part horizontally throughout the agar, and which in the marginal region extend considerably beyond the surface layer. The vertical hyphae arise from the horizontal hyphae, and hence the surface layer is much thicker at the center than near the margin. I have also noticed a somewhat similar pattern of growth for the intramatrical hyphae of certain species of *Streptomyces*.

The most remarkable feature of these unusual forms is the production of sporangia with zoospores. On boiled *Paspalum* grass leaves and certain other culture media in water the sporangia appear after about ten days in all the isolates so far obtained except one (H11G), while only a few form on agar. The sporangia as a rule are formed on leaves close to the surface of the water on short stalks, which project up above the surface a short distance in the air. Such sporangia may be easily broken off with or without part of the stalk to be disseminated by wind or water. Sporangia are also formed beneath the surface in some species on lateral as well as terminal branches and then show a rather striking, if superficial, resemblance to the more tenuous members of the Cladochytriaceae as *C. tenue*. Sporangia, mature in size but with undifferentiated spores, may remain in a resting condition for weeks, or until they are disturbed by a change of water or by mounting them on a slide. Such a change induces spore formation in from a half to one hour. Before spore formation starts, the protoplasm of the sporangium is evenly and finely granular with many small vacuoles dispersed throughout. Next one can see numerous small pale or yellowish globules, and then the spores become evident, each containing one of the globules. At this stage in some species the spores show a distinct spiral arrangement within the sporangium. It is very interesting to compare some of Drechsler's (1919) figures as 41 and 51, in which he shows the conidia formed in compact coils, very suggestive of the arrangement of the zoospores in the forms here discussed. In some species the zoospores are set free by the gradual but complete dissolution of the sporangial wall, in others part of the wall dissolves and part remains, and in others an irregular opening is formed in the wall through which the spores emerge. When set free the spores swim actively for a few minutes to several hours. The zoospores have been observed under dark field and with a phase microscope, but very little could be made out about the flagella

while the spores were in motion or even while they were quiet. Sometimes as a spore slowed down, a single flagellum could be seen with a thick basal part and a thin end part attached at the front of the spore, but bending backward as the spore swam. In one of the first mounts examined under the dark field and phase microscope there were swimming zoospores of the large chytrid *Karlingea rosea*, the flagella and thin whip lashes of which were remarkably clear. It is of interest to note that in all the chytrid zoospores I have examined with the dark field the flagella have been very distinct even on the most minute spores. If killed with 1% osmic acid fumes and stained with gentian violet about one out of five of the spores showed a thick basal flagellum and still fewer showed the tenuous portion. Loeffler's stain as used by me (1941) failed to reveal any structures that could be identified as flagella. While the exact nature of the organs of locomotion remains obscure it appears quite certain that they are not like those of any of the aquatic Phycomycetes, but rather are more like those found in certain bacteria.

In one of the species isolated from soil in Chapel Hill (D.S. 34) sporangia are formed on some agars and on *Paspalum* grass leaves in water. When mature, and disturbed as by mounting on a slide in water, the sporangial walls are partly hydrolyzed and the spores are set free in enormous quantities, but are non-motile. So far as observations have gone, this is the only type of spore produced by the present form. On grass leaves in water and on certain agars this species produces aerial hyphae much as in *Streptomyces*, and it seems very likely that this is a connecting form between the sporangial species with zoospores and *Streptomyces*.

Most bacteriologists treat the Actinomycetales as an order in the higher bacteria. In Waksman's and Henrici's recent classification three families are recognized, the Mycobacteriaceae with rudimentary or no mycelia at all, and then the two families, Actinomycetaceae and Streptomycetaceae, both with branched mycelia. In the first of these two no conidia are formed, and the vegetative mycelium divides by segmentation into bacillary or coccoid arthrospores, while in the second the vegetative mycelium is usually not divided into arthrospores, and conidia are formed on proper media. This latter family, the Streptomycetaceae, contains two genera: *Streptomyces*, in which conidia are formed in chains on aerial hyphae, and *Micromonospora*, in which conidia are formed singly on the ends of hyphae, or in small clusters, but not in chains. In *Streptomyces* a very characteristic aerial mycelium is formed, while in *Micromonospora* aerial mycelium is lacking or produced very sparingly. Thus the surface of *Streptomyces* on agar has a myceloid or dusty appearance, while the surface of *Micromonospora* usually is wet and slimy. From vegetative characteristics alone the sporangial forms seem closest to *Micromonospora*. This genus is characterized by Jensen (1930–31) as follows:

Actinomyces-like organisms, forming a mycelium of delicate, non-septate hyphae, 0.3–0.8μ thick, without aerial mycelium (or traces, then without spores), but producing spores singly on the distal ends of short lateral branches of the vegetative mycelium; spores spherical to oval, 1.0–1.2 $\times$ 1.2–1.5μ. Mycelium

and spores Gram-positive, not acid-fast. Aerobic organisms, most frequently met with in soil. The type species is *Micromonospora chalceae* (Foulerton).

In none of the sporangial forms were the minute spores supposedly so characteristic of *Micromonospora* formed. Could it be possible that the sporangia had been overlooked by former investigators of this genus? To test this possibility I tried to get authentic cultures of this genus from various workers in this group, but so far have been unable to get cultures of *M. chalceae* or *M. fusca*, two of the better known species. Through the kindness of Dr. S. A. Waksman I have been able to study *Micromonospora* #3450, which produces abundant small spores but does not form sporangia on any of the culture media tried. I have isolated from the soil several species which obviously belong to the genus *Micromonospora*, but none of these have produced sporangia, though some produce microspores in vast quantities in *Botrytis*-like clusters. There can be no possibility of confusing the conidia in *Micromonospora* with the sporangia in the present group, since the spores never exceed 2μ in diameter while the sporangia vary from 5–20μ thick. These forms which bear sporangia are closely related both to *Streptomyces* and *Micromonospora*, but are so strikingly distinct in having zoosporangia and zoospores as to make necessary placing such species in a new genus.

The present paper is intended, however, merely to announce the discovery of sporangia and zoospores in the order Actinomycetales. The detailed description of the genus and the several species on which it is based will be published later.

The writer is deeply indebted to W. Lane Barksdale for the soil samples from which the first isolations were made.

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THE EARLY DEVELOPMENT OF *HAPLOSCOLOPLOS BUSTORIS* (EISIG)[1]

By Edward C. Horn and C. G. Bookhout

Department of Zoology, Duke University and Duke Marine Laboratory, Beaufort, N. C.

Plates 1–4

INTRODUCTION

The development of members of the polychaete family Orbiniidae (Ariciidae), to which *Haploscoloplos bustoris* belongs, has not been investigated thoroughly. The development of two European species, *Aricia foetida* and *Scoloplos armiger*, which deposit the fertilized eggs in egg cases, has been described to some extent by several authors (reviewed by Thorson, 1946). Since the development of *H. bustoris* appears to be less specialized, however, it offers a better opportunity for comparison with the members of other families. A further purpose of this study is to supply sufficient morphological data of swimming stages to permit their future identification from isolated specimens in plankton studies.

MATERIALS AND METHODS

Haploscoloplos bustoris is the largest of five species of Orbiniids found in the region of Beaufort, North Carolina; it is easily distinguished from the other four by its size and distribution of branchiae (Hartman, 1945). Living in sand or in mixtures of sand and mud, this species is found in greatest numbers at Beaufort at the low tide mark or a few feet below along the edge of sandy shoals. Large, mature worms sieved up off Pivers Island from May through September were returned to the laboratory in jars of sea water where they were washed free of sand and placed in fingerbowls of filtered sea water. Since *Haploscoloplos* never sheds eggs or sperm naturally in the laboratory, the gametes had to be collected artificially. This was accomplished by finely dividing two or three whole males in a petri dish of filtered sea water containing five to seven finely divided females. The eggs and sperm thus liberated were separated from

[1] Aided by a grant from the Duke University Research Council.

the tissue masses by straining the contents of the petri dish through fine silk bolting cloth into a small fingerbowl of filtered sea water. The supernatant fluid was drawn off several times and replaced with fresh filtered sea water. This procedure yielded about 45% cleavage, but development into healthy larvae occurred in approximately only 1% of the total eggs. The removal of all dead eggs and larvae was imperative, while the subculture of healthy larvae seemed helpful.

Diatoms were added to some cultures of older larvae. Other larvae were placed in glass tubes closed at either end with plankton netting and suspended in tidal currents. To still other cultures a variety of sand and mud combinations were offered as substrata for the developing larvae. Despite every attempt to furnish the larvae with what seemed to be an adequate environment none of our cultures survived beyond the thirteenth day. Furthermore, there seemed to be little development beyond the ninth day.

At close intervals larvae and juveniles of various stages were fixed in Bouin's fluid heated to 60°C. Whole mounts were made in oil of cedar after staining in alum cochineal. For setae study unstained larvae were mounted in polyvinyl alcohol and examined under oil immersion.

Preliminary drawings of living larvae were made on squared graph paper with the aid of a Whipple micrometer disc in the eyepiece. All drawings of fixed larvae were made with the aid of a camera lucida.

We wish to thank Mr. Stanley Rhodes and Mr. Leon Hayes for technical assistance. We appreciate the facilities offered by the Duke Marine Laboratory at Beaufort.

OBSERVATIONS

Early Development

The method which was used to obtain fertilization results in uneven development, and, hence, it was not uncommon to find a wide variety of stages at any given time during cleavage.

Twenty minutes after cutting up the worms in sea water a fertilization membrane could be detected on some of the eggs. The first polar body was found 40 minutes after fertilization and the first cleavage one hour later. Two hours and 40 minutes after fertilization 4- to 16-cell stages were present. The eggs, cream colored in the living condition, are very opaque and cleavage is not easily followed. The fertilized egg measures about 160 μ in diameter.

Larval Development

16-hour larva. Thirteen hours after fertilization an early motile larva could be recognized. At 16 hours the typical trochophore larva is positively phototropic for the first time. It possesses a prototroch, a broad continuous band of uniform cilia (fig. 1, proto), and a narrow ciliated band posteriorly, the telotroch (fig. 1, telo); the cilia of the latter are uniform in length except on the dorsal side where they are somewhat shorter (fig. 2, telo). No neurotroch, apical tuft, nor caudal filament could be found. The prototrochal cells appear to be

large and vesicular, but this condition does not exist in the telotrochal region. The gut endoderm (fig. 1, endo) is quite opaque and granular but it already possesses a lumen. A stomodaeum (fig. 2, stomo) is pushing through into the endoderm and probably opens into the gut lumen at this stage. From ventral view a mesodermal sheet (fig. 1, meso) can be seen between the ectoderm and endoderm except in the head region. From side view (fig. 2) it cannot be detected because it has not extended dorsally or ventrally. The ectoderm appears uniform in density except in the region of the prototroch where there are the already mentioned, large, translucent cells.

23-hour larva. From figures 3 and 4 it can be seen that the larva is longer and the mouth opens into the lumen of the gut. In the exact median line a narrow uniformly ciliated band, the neurotroch (fig. 5, neuro) extends from a point just posterior to the mouth to a point just short of the telotroch. At this stage the telotroch consists of cilia of uniform length. A third ring of cilia, the metatroch (figs. 3, 4, 5, and 6, meta), appears for the first time, encircling the larva posterior to the mouth. In addition there are three smaller tufts of cilia equidistant from the metatroch and from each other. They are confined to the ventrolateral surface and are not contiguous with the neurotroch (see figs. 4 and 5, seg).

The bands of mesoderm are prominent laterally (fig. 3, meso) but cannot yet be detected dorsally or ventrally. The ectoderm is lighter than the endoderm and its cells exhibit many mitotic figures. The cells of the anterior end seem to be columnar.

39-hour larva. The period from 23 hours to 39 hours is one of elongation. The 39-hour larva appears more worm-like and less like a larva. The prototroch ventral and anterior to the mouth is composed of one band of cilia, but laterally it splits into two bands (fig. 7, proto a, proto p), one at the level of the cerebral ganglia (fig. 7, cg) and a posterior one at the level of the mouth. The posterior band is incomplete dorsally but the anterior band is complete. There has been no change in the metatroch from the 23-hour stage, but the ventrolateral tufts have now extended further around the larva as segmental bands, leaving only a narrow gap dorsally. In addition three similar segmental bands of cilia have been added posteriorly (fig. 7, seg). Each band is located on what will be the center of a body segment. Thus, the peristomium in the vicinity of the mouth represents the first body segment, the metatroch is on the second segment and the six ciliated bands denote segments 3 through 8. The terminal pygidium represents the ninth segment. The neurotroch extends from the second segment posteriorly to the eighth segment. It is composed of cilia uniform in length, but shorter than the cilia in any other ciliated bands of the body. See Table 1 for a summary of the various ciliated bands which appear during larval development.

In fixed preparations large clear cells appear around the periphery in the prostomium and pygidium. There is also a row of clear cells in the epidermis associated with each of the segmental ciliated bands. From optical sections it appears as though the mesodermal bands are solid. The proctodaeum has not

broken through to form an anus. Strands of the circumpharyngeal connectives can be seen running from the cerebral ganglia to either side of the pharynx. On the dorsal surface lateral to the ganglia reddish-brown eye spots can be seen.

40-hour larva. Setae occur at this stage for the first time. They are present as a single pair of notopodial setae on the third and fourth segments, and they apparently appear simultaneously. A pair of ciliated pits or nuchal organs can be seen clearly on the dorso-lateral surface between the two prototrochal bands. The appearance of a seventh ciliated band indicates the addition of another body segment making ten in all. The split into anterior and posterior prototrochal bands has developed almost to the mid-ventral line.

TABLE I

Occurrence of cilia at different larval stages

	16 HRS	23 HRS	39 HRS	40 HRS	49 HRS	70 HRS	3 DAYS, 6 HRS	3 DAYS, 16 HRS	4 DAYS, 17 HRS
Ant.			+	+	+	+	+	+	
PROTOTROCH	+	+							0
Post.			+	+	+	+	+	+	
METATROCH	0	+	+	+	+	+	+	+	0
SEGMENTAL BANDS									
Seg. 3	0	+	+	+	+	+	+	+	0
Seg. 4	0	+	+	+	+	+	+	+	0
Seg. 5	0	+	+	+	+	+	+	+	0
Seg. 6	0	0	+	+	+	+	+	+	0
Seg. 7	0	0	+	+	+	+	+	+	0
Seg. 8	0	0	+	+	+	+	+	+	0
Seg 9	0	0	0	+	+	+	+	+	0
TELOTROCH	+	+	+	+	+	+	+	+	0
NEUROTROCH	0	+	+	+	+	+	+	+	0

49-hour larva. The ciliation pattern is the same as at 40 hours, but an additional seta is present in the notopodial bundle of segments three and four. Thus, there are two notopodial capilliform setae per bundle on segments three and four and one notopodial seta on segment five. From a side view (fig. 8) it can be seen that the anterior prototrochal (proto a), metatrochal, and telotrochal bands are the only ones which are complete dorsally; although not shown in figure 8 only the prototroch and telotroch are complete ventrally, the neurotroch interrupting both metatroch and segmental bands.

70-hour larva. The ciliated bands are still present as in the previous stage, but as shown in Table 2 six segments possess setae. All except the last setigerous segment has notopodial and neuropodial bristles. Of the setae in the notopodial bundle two are long and serrate while one is short and appears nonserrate. The same condition exists in the neuropodial setae when three are present, but

when two or one is present they are clearly serrate. All short, nonserrate, capilliform setae will become serrate as they develop.

One pair of dorsal wing-like branchial lobes appears on the tenth segment just anterior to the pygidium. There are also two conical anal cirri present for the first time.

At this stage the mesodermal band can be seen clearly between the gut and ventral epidermis. The beginning of the coelomic cavity can be seen for the first time in the anterior region of the body around the pharynx.

Larva of 3 days, 6 hours. Both anterior and posterior portions of the dorsal prototroch have disappeared, but both bands are present laterally. The anterior ventral part of the prototroch is represented by a few scattered cilia, but the posterior ventral band is still present although reduced from the condition at 70 hours. There have been no changes in the metatroch or in the telotroch. The neurotroch extends from the mouth back to the eighth segment. The ciliated bands from the third to the ninth segments are still well developed. The ninth segment is now setigerous and more setae are found in the notopodial and neuropodial bundles than at 70 hours. See Table 2. This stage is evidently at the onset of metamorphosis

Larva of 3 days, 16 hours. At this stage there are only a few scattered cilia of the anterior prototrochal band laterally and dorsally, but the posterior band of the prototroch is not reduced laterally. There are no remnants of the prototroch ventrally. The neurotroch is reduced to patches on the third, fourth, fifth, sixth, and seventh segments. The segmental ciliated bands are now confined solely to the ventro-lateral parts of each segment. The metatroch is somewhat reduced, but it is still a complete band, while the telotroch is still well formed. Metamorphosis is nearly complete

From figure 9 it can be seen that the gut is completely separated from the body wall for the first time. The dorsal and lateral body wall is thin and covered by simple cuboidal epithelium, whereas the ventral wall is thick, preparatory to nerve cord formation. Constrictions can be seen in the body wall which denote the limits of the segments, but septa could not be detected from optical sections.

The cerebral ganglia consist of a pair of large spherical bodies in the prostomium (fig. 9, cg) surrounded by many spherical nuclei. In the ventral portion of the prostomium there are several large vacuolated cells. Similar cells are still present at the posterior end of the pygidium and isolated cells in each segment of the ventral body wall.

Large wing-like branchiae are found on the dorso-lateral border of the tenth segment, and a smaller pair of branchiae appear on the eleventh segment (fig. 9, br2). Cilia along the posterior border of the first pair of branchiae are prominent and comb-like. The anal cirri (fig. 9, ac) at this age are longer and bear a few short terminal cilia.

Optical sections reveal a differentiation of the gut into a mouth, pharynx, esophagus, stomach, intestine, and a terminal anus. The pharynx is in the peristomial or first body segment and is thick-walled. The esophagus is thin-

walled, contorted, and present from the second through the fourth segments. The stomach has a broad lumen and extends from the fifth segment to the seventh. The intestine is thin-walled and extends from the eighth segment to the anus at the end of the pygidium.

Juvenile of 4 days, 17 hours. This stage marks the disappearance of all ciliated bands, hence, it is considered a juvenile, not a larva. The only cilia present are

TABLE 2

Number of setae per segment and their order of appearance

BODY SEGMENT	40 HRS	49 HRS	70 HRS.	3 DAYS, 6 HRS	3 DAYS, 16 HRS	4 DAYS, 17 HRS,	7 DAYS
1							
2							
3 {Noto Neur	1 0	2 0	3 3	3 3	3 3	4 3	4 3
4	1 0	2 0	3 2	3 3	3 3	3 3	4 3
5	0 0	1 0	3 2	3 3	3 3	3 3	3 3
6	0 0	0 0	3 2	3 2	3 3	3 3	3 3
7	0 0	0 0	3 1	3 1	3 3	3 3	3 3
8	0 0	0 0	2 0	2 0	2 1	3 3	3 3
9	0 0	0 0	0 0	1 0	1 0	2 1	3 3
10	0 0	0 0	0 0	0 0	0 0	2 1	2 2
11			0 0	0 0	0 0	0 0	0 0

a few scattered cilia of the prototroch anterior to the mouth. As shown in Table 2 there are 8 setigerous segments. Both pairs of branchiae are large and are ciliated along their posterior borders. The coelomic cavity is more extensive, and dorsal to the gut there is a large blood vessel.

Juvenile of 5 days, 17 hours. A third pair of branchiae appear for the first time on the twelfth segment. Septa also are discernible for the first time separating every segment from three to nine. The pharynx and esophagus occupy the same

segments as at 3 days, 16 hours. The stomach occupies one less segment and extends from the fifth to sixth rather than from fifth to seventh segments. The intestine is now divided into two regions; an anterior part which is coiled and extends from the seventh segment through the ninth and a second part with a broader lumen which extends from segment 10 through 12 (see figure 10).

Juvenile of 7 days. The general anatomy of a juvenile at this stage does not differ from the one at 5 days, 17 hours. Two neuropodial setae are now present on the tenth segment, whereas none was present in the previous stage. Two more septa are discernible, occurring between the ninth and tenth segments and between the tenth and eleventh segments. Minor differences exist in the digestive system (see figure 11).

On the posterior border of each segment from 6 through 9 there occurs one pair of dorso-lateral projections believed to be parapodial lobes (fig. 12, pl). They are much smaller than the large branchiae, but they later become progressively larger in each segment after the sixth.

As already mentioned, juveniles maintained beyond this stage showed no marked changes, hence, their descriptions have been omitted.

DISCUSSION

The two members of the family Orbiniidae (Ariciidae) whose development has been described previously demonstrate stages similar in appearance to those of *H. bustoris*, but differ in certain details. Both *Aricia foetida* and *Scoloplos armiger* deposit their eggs in jelly masses; apparently *H. bustoris* does not produce an egg case although these have been looked for at different seasons. The early larvae of *Haploscoloplos* possess in addition to prototroch, metatroch, telotroch, and neurotroch a series of segmental bands of cilia which are not described or figured for *S. armiger* by Cunningham and Ramage (1887) but which are briefly alluded to by Eisig (1914) in his description of *A. foetida*. These accessory bands of cilia are normally correlated with a more prolonged pelagic existence (Spionidae) than the short (about 3½ days) stage exhibited by *Haploscoloplos*. From what is known of *Aricia* this same incongruity appears to exist. The stage figured by Cunningham and Ramage (1887) for *S. armiger* as the most advanced they studied bears a striking resemblance to the latest *Haploscoloplos* we studied except for setigerous segments and gills. *Scoloplos* is figured as possessing 11 setigerous segments and two pairs of branchiae on the next two successive segments; *Haploscoloplos* at a comparable stage possesses 9 setigerous segments and three pairs of branchiae, the first pair of which occurs on the eighth setigerous segment.

The first appearance of dorsal setae in segments 3 and 4 simultaneously (none ever occur in segments 1 and 2 here) correlates well with the first appearance of setae in other polychaete larvae (Wilson, 1932, 1936a and 1936b; Segrove, 1941; Bookhout and Horn, 1949).

It is noteworthy—and as yet inexplicable—that the paired dorsal branchiae of *Haploscoloplos* arise in the 70-day larva on the tenth segment (eighth setigerous segment) and appear later in development on successive segments. A

distinguishing feature of the adult *H. bustoris* is the presence of branchiae no further anterior than the twenty-fourth segment. One might assume that a loss of gills occurs from the tenth through twenty-third segments during the development of the pre-adult; according to Eisig (1914), however, the gills of *Aricia* are present from the tenth segment posteriorly in both the adult and larvae, never more anteriorly. Here then there is no loss of gills during development. In passing it is also interesting to note that gills first appear on the same segment (10) in the larvae of both species.

SUMMARY

1. The development of *Haploscoloplos bustoris* through larval and early juvenile stages was studied from eggs and sperm artificially procured.

2. The early larvae are typical trochophores in that they possess a broad prototroch, a telotroch, and a narrow neurotroch. Later in their development the larvae possess the less typical metatroch and segmental bands of cilia in addition. The swimming stage lasts about three and one-half days when ciliation is lost and metamorphosis is accomplished.

3. Setae appear several days before metamorphosis. A table containing their order of appearance is given. Large, dorsal, wing-like branchiae appear on the tenth segment just before metamorphosis.

4. A brief discussion is given comparing the development of this species with that of the other two members of the family which have been studied.

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EXPLANATION OF PLATES

All drawings were made with the aid of a camera lucida from preserved material; finer details were sketched in. All plates were reduced one-half. Magnifications are for the reduced plates.

PLATE 1

Fig. 1. Optical section of 16-hour larva seen in ventral view. ×210

Fig. 2. Same larva as in fig. 1 seen from right side. ×210

Fig. 3. Optical section of 23-hour larva seen in dorsal view. ×210

Fig. 4. Same larva as in fig. 3 seen from left side and slightly dorsal to show segmental bands of cilia. ×210.

Fig. 5. External appearance of 23-hour larva seen in ventral view. ×210

Fig. 6. Same larva as in fig. 5 seen from left side. ×210

PLATE 2

Fig. 7. Optical section of 39-hour larva seen in dorsal view. ×210

Fig. 8. Optical section of 49-hour larva seen from left side and slightly dorsal to show segmental bands of cilia. ×210.

PLATE 3

Fig. 9. Optical section of 3-day, 16-hour larva seen from right side and slightly dorsal to show segmental bands of cilia. ×210.

Fig. 10. Optical section of contracted 5-day, 17-hour larva seen from left side. ×210

PLATE 4

Fig. 11. Optical section of 7-day larva seen in ventral view. ×210

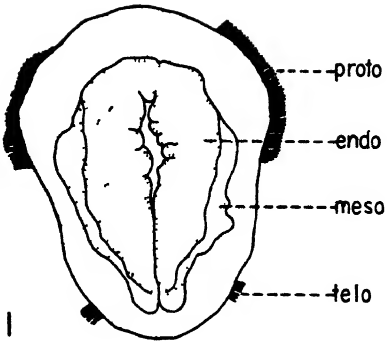
Fig. 12. External appearance of 7-day larva seen in dorsal view. ×190

ABBREVIATIONS

Roman numerals indicate body segments

a, anus
ac, anal cirrus
br 1, 2, etc., branchia
c, coelom
cg, cerebral ganglion
e, esophagus
endo, endoderm
es, eye spot
i, intestine
m, mouth
meso, mesoderm
meta, metatroch
neuro, neurotroch
p, pharynx
pl, parapodial lobe
proto, prototroch
proto a, anterior division of prototroch
proto p, posterior division of prototroch
seg 1, 2, etc., segmental ciliated bands
sep 1, septum 1
st, stomach
stomo, stomodaeum
telo, telotroch

PLATE 1



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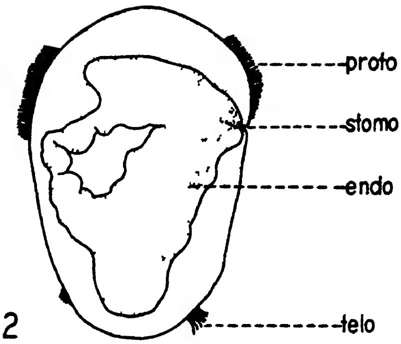

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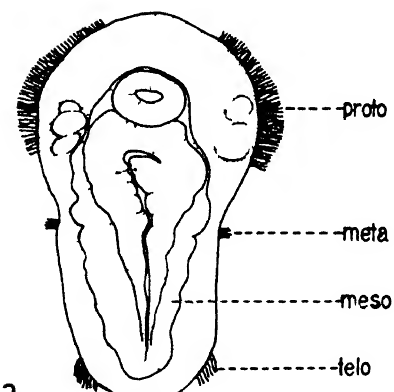

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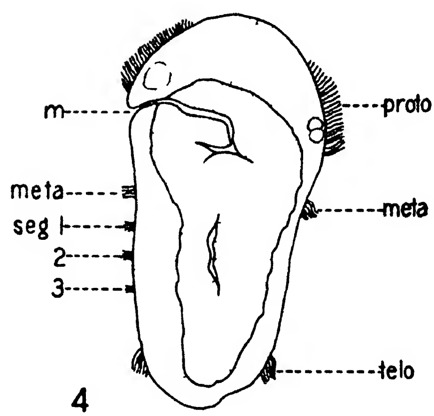

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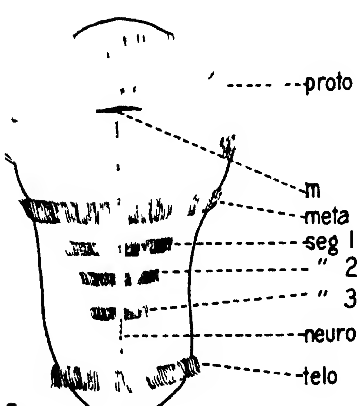

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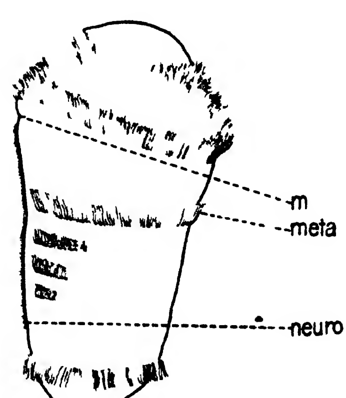

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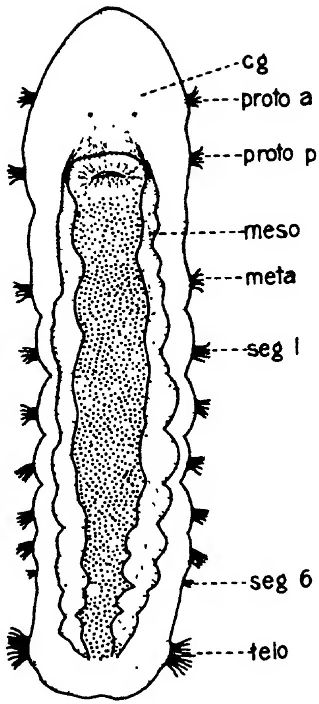
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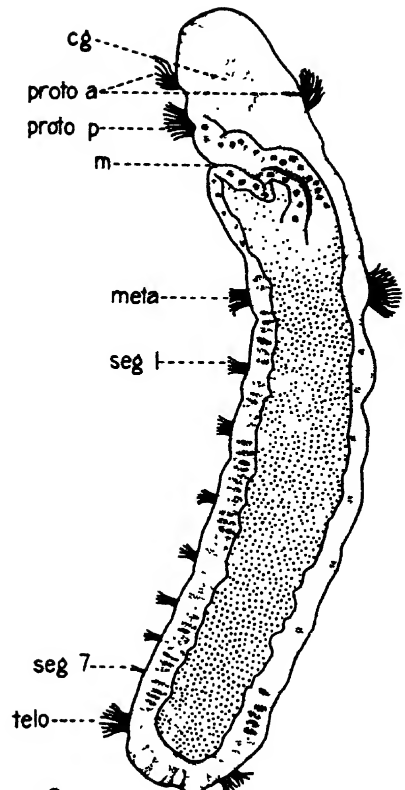
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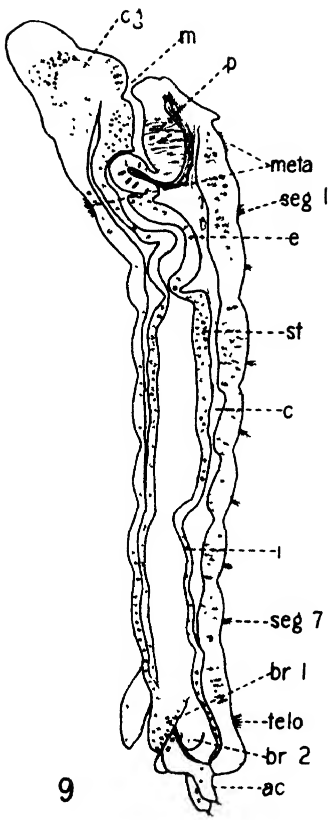
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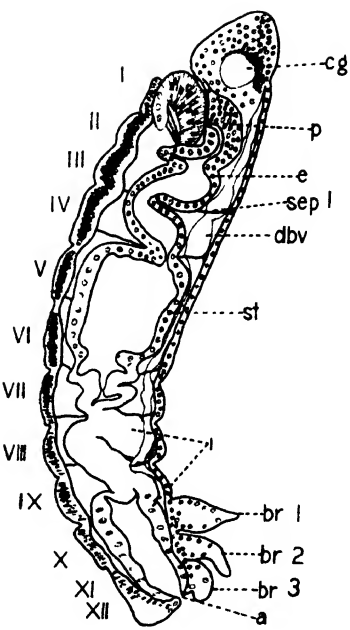
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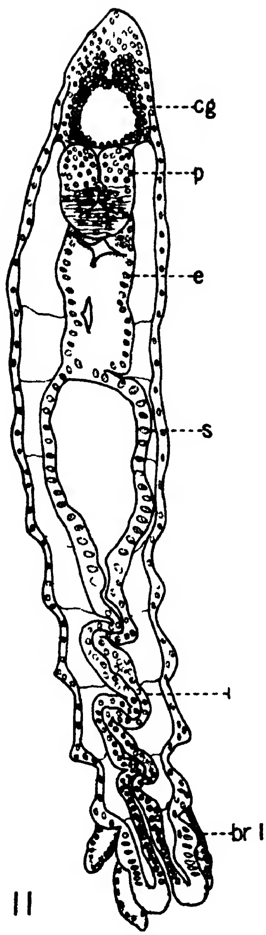

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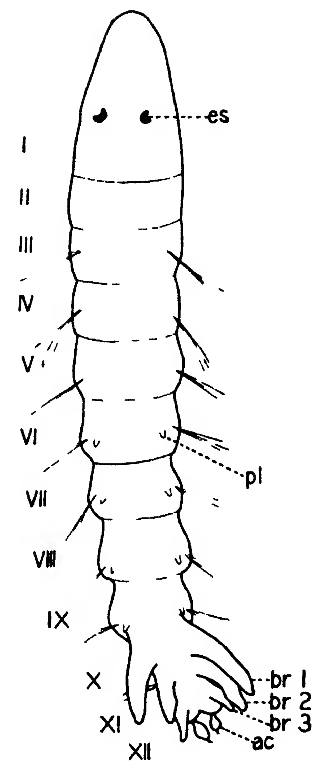

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RECORDS AND DESCRIPTIONS OF DIPLOPODS FROM THE SOUTHERN APPALACHIANS

By Richard L. Hoffman

Highlands Biological Station
Highlands, North Carolina

Plates 5–8

During the month of July 1949, I was fortunate in being able (through the aid of a scholarship from the Highlands Biological Station) to carry out studies on the diplopod fauna of the extreme southeastern Appalachians.

The great majority of collections were made in eastern Macon County, N. C., since a faunal study of the Highlands Plateau was the main objective of the work. However, it was possible to participate in several trips to adjacent localities, and the results thereof may profitably be included in this report.

Insofar as was possible, I made field notes on the ecology of the species obtained, and the more interesting of these are incorporated herein. Although most of the work was of a systematic nature, there seems to be every indication that future collecting will add a number of forms to the known fauna of the Highlands Plateau. Field work in the months of May, June, and October would be especially valuable in this respect.

In addition to recording new localities and ecological notes on established forms, this report includes the description of nine new species, the proposal of a new generic name, and taxonomic notes and changes involving several species.

The following data, condensed from Quarterman and Keever (1947), are pertinent to the collections made in the Highlands area.

"Records of the Highlands Weather Station show an average annual rainfall of 81.73 inches, and average temperatures as follows: June, 64.2; July, 66.5; August, 65.7; annual, 50.5.

"The area contains numerous mountains, both large and small, the slopes of which are usually steep. The south and east sides of most of the mountains are often nearly vertical, granite cliffs with a scanty flora; while the north-facing slopes, although sometimes very steep, show less bare rock and are covered with abundant vegetation. A few of the hills and low mountains have gentle slopes. Many of the small streams that drain the area flow so swiftly that they have washed out deep gorges and formed numerous water falls, varying from gradual cascades over inclined rocks in the stream bed to a sudden drop of many feet, as at Dry Falls.

"There are a number of easily recognized plant communities, with all degrees of transition between them. All undisturbed mesophytic areas are covered with stands of oaks and hickories, the species varying with local conditions. There are a few dead chestnut trees standing, remnants of the time before the chestnut

blight struck in 1927, when the chestnuts held a place with the dominant oaks and hickories.

"Both north and south slopes support an oak-hickory climax. The trees on the north side, however, are larger in diameter and height, and form a more closed canopy than those on the south sides. The understory in the oak-hickory forests is composed of seedlings of oaks and hickories, with many chestnut sprouts, and an abundant growth of laurel, rhododendron, azalea, red maple, cherry birch, and other less numerous small trees and shrubs. The undergrowth on the south slopes is often more dense and thicket-like than on the shaded north-facing sides. Although northern exposures do not show the extreme denseness of vegetation found on the south, many more species are represented in the ground cover there, including ferns, galax, and other shade-loving herbaceous plants.

"There is a distinct type of vegetation along the stream margins and in the small coves formed by the streams. The dominant trees in such places in higher altitudes of the range are invariably hemlock, with some magnolia, red maple, cherry birch, and yellow poplar consistently present, but never attaining the height of the hemlocks. Where the streams are so oriented as to cause a difference in the amount of light received, there is a noticeable difference in the understory plants on the shady and sunny sides. The understory on the shady side is often composed almost entirely of very large rhododendrons forming such a dense shade that only dog hobble, galax, and a few ferns and mosses grow under them. On the sunny sides of the streams, the rhododendron is less dense, and is usually accompanied by laurel, hydrangea, clethra, silver bell, tulip poplar, and seedlings of cherry birch and maple. There is very little hemlock along Big Creek at the lowest altitude of the area. The dominant trees along the stream banks there are red maple, sycamore, and yellow poplar, with the oaks and hickories on the slopes just above."

Since I have discovered from previous experience elsewhere that moist oak-hickory forest contains definite milliped inhabitants, and that certain others are restricted to the hemlock-magnolia "cove forest," most of the collections were made in these two habitat types. Survey collections in other areas—cultivated fields, pastures, etc., and rather dry mountain tops were mostly unproductive (although in Virginia dry exposed mountains often yield large numbers of *Cleidogona!*).

Obviously, comments on the origin and affinities of the Highlands diplopod fauna would be of interest, but considerable supplementary work is prerequisite. At the moment only a few observations may be made in this connection. A most singular situation is the apparently close similarity of the fauna to that of the Great Smokies; this is evidenced particularly by the occurrence of *Howellaria deturkiana* as well as some other species in both regions. It is my understanding that the relationship holds in other animal as well as plant groups.

The occurrence at Highlands of a number of species in groups heretofore restricted to the Southeastern Piedmont is of considerable interest. Good examples are *Onomeris australora* and *Spirostrephon highlandensis* whose closest

relatives occur in central and northern Alabama. The families represented by these two forms (Glomeridae and Lysiopetalidae) are both well represented in Europe and Eurasia.

The majority of the material obtained is retained in my personal collection. All types and the material collected in the Great Smoky Mountains are deposited in the collection of the U. S. National Museum. A series of specimens of the commoner species was presented to the Highlands Biological Station, to be deposited in its Museum of Natural History.

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My debt to my parents is great and long-standing, in connection with this as with most of my other endeavors.

This investigation was made possible by a grant to the Station by the Champion Paper and Fibre Co. of Canton, North Carolina.

Order ONISCOMORPHA

Family *Glomeridae*

Onomeris australora, new species

Plate 5, figs. 1, 2

Type locality.—Reed Creek Falls on Glade Mountain, Rabun County, Georgia (about 5 miles south of Highlands, N. C.).

Type specimens.—Male holotype and four female paratypes, U. S. Nat. Mus. no. 1872; several female paratypes in my personal collection; all collected July 27, 1949.

Diagnosis.—Similar to *O. underwoodi* in most characteristics and possibly

referable to that species. Nineteenth legs of male and female genitalia as illustrated.

Description.—Length, 5.6 mm.; maximum width, 2.5 mm. Dorsum smooth, shining, without fine pubescence.

Seventeenth legs of male three-jointed. Eighteenth legs with joints of about equal thickness, the distal two not abruptly smaller as shown by Loomis (1943: 375) for *Trichomeris sinuata*. Nineteenth legs generally similar to those of *T. sinuata*, differing especially in the large, distally bifid sternal plate bearing a median accessory process, and in the much longer basal processes from the second joints. The third and fourth joints have conspicuous finely corrugated median projections.

Female genitalia attached to sternites of second pair of legs; composed of box-like basal receptacles, each enclosing a set of small valves as figured.

Dorsal color dominantly light brown with a very large oval light blotch on the anterior half on each side of the segments. Ground color darker along middle of back and lateral margins of tergites.

Relationships.—As mentioned above, this form may prove to be the same as *O. underwoodi* Cook (1896: 44), described from Auburn, Alabama. However, the types of *underwoodi* cannot at present be found, and I hazard the description of this montane population on the basis of the unlikelihood that *underwoodi* has such a wide horizontal, vertical, and ecological range. The terminal male legs will doubtless show specific differences when specimens of *underwoodi* become available for study.

Ecology.—At the type locality specimens were found in deep, moist humus in a very dense rhododendron thicket. Immature specimens were abundant near the surface, but adults could be obtained only by going under the loose leaf mold and into the soil itself. Elsewhere I have taken this species principally under large sheets of bark which had fallen from chestnut trees, associated with *Striaria zygoleuca* in particular.

O. underwoodi was found, according to Cook, in rotting leaves and pine needles at Auburn, Alabama. This is of interest inasmuch as very few diplopods are to be found in evergreen woods.

The name *australora* alludes, of course, to the Southern Blue Ridge where the species occurs.

Georgia. Rabun County: Glade Mountain at Reed Creek Falls, six mature specimens taken July 27, 1949.

North Carolina. Macon County: Satulah Mountain at Highlands, many females taken July 20–24, 1949, elevation 4100 feet.

Order COLOBOGNATHA

Family *Polyzoniidae*

Polyzonium bivirgatum (Wood). Proc. Acad. Nat. Sci. Philadelphia, p. 186, 1864.

A single subadult specimen in which the caudal margin of the tergites is nar-

rowly edged with dark brown; taken in company with ***Brachycybe petasata*** in leaf mold at the base of a beech tree (*Fagus grandifolia*).

Tennessee. Sevier County: along Alum Cave Trail, from Rt. 71, north side of Newfound Gap, Great Smoky Mountains National Park, July 28, 1949.

Family *Andrognathidae*

Brachycybe lecontei Wood. Proc. Acad. Nat. Sci. Philadelphia, p. 187, 1864. Loomis, Proc. U. S. Nat. Mus. **83:** 366, 1936.

This little known species was obtained at two localities, each representing a new state record for North and South Carolina, respectively. *B. lecontei* has been reported from Balsam Gap and Sunburst in the former state, but it is felt that these records actually apply to the following species.

In life, *lecontei* when adult is of a very attractive peach color, the legs somewhat lighter. Immature specimens are white as usual in diplopods.

An adult male, with 47 segments and measuring 16 x 3.7 mm., was discovered on Satulah Mountain near Highlands. It was observed ascending a small tree, about three feet from the ground, and fully exposed to the morning sun.

The immature specimen from Jocassee, with 37 segments and 13 mm. in length, was found in leaf mold under *Kalmia*, on a dry hillside in oak woods.

Originally described from northern Georgia, this species has been definitely reported only from Tallulah Falls in that state (Loomis, *op. cit.*). It is likely that *lecontei* inhabits the southern extremity of the Blue Ridge proper, and that its place is taken further north (*e.g.*, in the Smokies and Balsams) by *B. petasata.*

North Carolina. Macon County: east side Satulah Mountain at Highlands, July 23, 1949.
South Carolina. Oconee County: Jocassee, July 14, 1949.

Brachycybe petasata Loomis. Proc. U. S. Nat. Mus. **83:** 365, 1936.

Two immature specimens, with 30 and 38 segments, were found in company with *Polyzonium bivirgatum* in moist but loose leaf mold at the base of a beech tree, July 28.

The color, not heretofore known, is very distinctive from that of *lecontei* (*q.v.*). "Color in life very bright pink with a vermilion cast, dorsally and on undersides of keels; legs white; head, antennae, and collum yellowish gray."

It would seem that members of the genus *Brachycybe* have a definite predilection for beech woods. These trees were present at the Highlands station for *lecontei;* and a number of specimens of an undescribed species taken in West Virginia are noted to have been found crawling on logs in beech woods! This association is certainly worthy of investigation by ecologists.

The following locality does not add to our knowledge of the distribution of the species, which has previously been found at Chimneys Camp in the Park (Loomis, 1943: 376).

Tennessee. Sevier County: along Alum Cave Trail, from Rt. 71, on north side of Newfound Gap, Great Smoky Mountains National Park, July 28, 1949.

Order CHORDEUMIDA[1]

Family *Striariidae*

Striaria zygoleuca, new species

Plate 5, fig. 3

Type locality.—Satulah Mountain, Highlands, Macon County, North Carolina, elevation 4100 feet.

Type specimens.—Male holotype and female allotype, U. S. Nat. Mus. no. 1873; eight topoparatypes of both sexes in my personal collection and one in the Highlands Museum.

Diagnosis—Distinct from all other members of the genus and family in the white color of the enlarged first segment. The terminal modifications of the male gonopod appear to be of specific value in diagnosis.

Description.—Length approximately 10 mm. as in other eastern members of the genus.

Agreeing in structural characters with *S. columbiana* and *S granulosa* as described in detail by Cook (1899: 675). The crests of the collum are very weakly developed, especially the median pair. Terminal segment trilobed, the notches only shallowly indented.

Male gonopods very complex, the terminal projections numerous and arranged as shown in the illustration. A seemingly characteristic flange-like development on the anterior side, this terminating in a slender spine, evenly curved laterad and caudad.

Dorsal color nearly uniform pale brown with a light median dorsal line, sides slightly lighter. Collum entirely white, in striking contrast with the rest of body. Underparts colorless to whitish-gray.

Relationships.—So little is known about the other eastern members of this genus (*granulosa* Bollman and *columbiana* Cook) that it is at present impossible to say anything definite about affinities. A careful study of good series of Striariae, including especially microscopic preparations of male genitalia, would probably reveal that the genus is excellent for zoogeographic and evolutionary investigations.

Ecology.—This species is definitely to be associated with hardwood forests on shady, well-drained hillsides. One can find numerous specimens by carefully lifting up the larger leaves and bits of bark in the upper humus layer. All of the specimens of this species (and others collected by me) have been found curled up. When placed in the hand or on a similar flat object the millipeds move about very awkwardly, usually waving the anterior third of the body about in the air. The type series of *zygoleuca* was taken in association with numerous immature specimens of the glomerid *Onomeris australora.*

The name *zygoleuca* refers to the white collum.

[1] This and the following ordinal names are those adopted for use in the forthcoming Checklist of North American Diplopoda.

North Carolina. Macon County: Satulah Mountain at Highlands, 4100 feet, July 20–24, 1949.

Tennessee. Sevier County: Chimneys Camp area, Rt. 71 between Newfound Gap and Gatlinburg, July 28, 1949 (two females provisionally placed here on the basis of color pattern.)

Family *Lysiopetalidae*

Spirostrephon highlandensis, new species

Plate 5, figs. 5, 6

Type locality.—Highlands, Macon County, North Carolina.

Type specimens.—Holotype and female allotype, U. S. Nat. Mus. no. 1874; several male and female topoparatypes in my personal collection and one deposited in the Highlands Museum, collected July 10–11, 1949.

Diagnosis.—Size very large, exceeding other known American lysiopetaloids, differing from *S. magnum* in having the usual six primary crests on posterior segments and from *lactarium* in much greater size and in the male gonopods.

Description of male holotype.—Length, 52.5 mm.; greatest width, 3.1 mm.; number of segments 58.

Eyes composed of 56 ocelli on the right side, 57 on the left, in 10 rows counting downward from the anterior corner, disposed as follows: 2, 3(4), 4, 5, 6, 7, 8, 8, 7, 6. Sense organ adjacent to the 5th and 6th rows of ocelli.

Antennae slender and rather short, not exceeding posterior edge of the fifth segment. Relative lengths of articles, from longest down, as follows: 3, 2, 5, 4, 6, 7, 1. The sixth is considerably swollen.

Collum with 20 even-sized crests.

Transition to full number of dorsal crests appears to take place on segment 10.

Two enlarged pleural crests below poriferous carinae, the tips of these bent slightly dorsad.

Primary and secondary crests differentiated over most of body. On segments posterior to 10th, there are three primary, four secondary, and four tertiary crests on each side of the mid-dorsal line.

Male gonopods large, black. Coxal process large, with a serrate angulation at midlength; distally truncate and bent laterad. Tibiotarsal portion broadly rounded distally. Branched process at base of tibiotarsus with two primary arms, nearly equal in size and length. The upper bears a small slender dorsal spine about one-third its length from the base; it is evenly tapered distad and slightly exceeds the lower arm. Latter evenly tapered to end, where expanded into a terminal cup-like development.

Color uniform dark brown dorsally with a yellowish narrow median stripe. Underparts and legs yellowish tan. Front of head light brown. Poriferous keels yellowish.

Description of female allotype.—Length, 45 mm.; width, 3.6 mm.; number of segments, 53.

Eyes composed of 55 ocelli on each side, in ten rows.

Agreeing with male in most other respects as regards structural characters. Color slightly lighter brown, with the middorsal light line broader than in the male.

Variation.—Of six type specimens at hand, the size ranges from 37.5 to 64 mm., both extremes represented by females. The average length for the series is 50 mm. The female 64 mm. in length appears to be the largest specimen known for the genus and the entire family as represented in North America.

The number of segments varies from 53 to 59, the two males having 57 and 58, the four females 53, 54, 58, 59. There seems to be no correlation between size and segment count, the female of 64 mm. having 59 segments, that of 37 mm. having 54.

Ocellus count varies slightly, the total number of 56 appearing to be the average. The ocelli are arranged in 10 rows, the median six of which (4th through 9th) are constant in number of ocelli. In one case there is ah extra single ocellus at the front corner, actually making a count of 11 rows. The tenth row may have either 5 or 6 ocelli.

Relationships.—In size of the animals and in the configuration of the male genitalia, this species is very close to *S. magnum* Loomis from northern Alabama. That form, however, is very distinct in the presence of eight primary crests on the posterior tergites. The gonopods of the two species are very similar, but in *magnum* the end of the coxal process is recurved caudad and is drawn out instead of being truncate.

Northward through the Appalachians occurs another very large *Spirostrephon* the description of which is in preparation. This species, of which material has been seen from North Carolina, Virginia, West Virginia, and New York inhabits the mountains to the exclusion of the smaller, lowland *lactarium*. It is very similar to *magnum* and *highlandensis*.

Ecology.—A decided preference for oak-hickory climax forest is noted for this species. It inhabits well-drained situations, and frequently occurs under stones in dry places, a trait also noticed in *S. lactarium* in central Virginia. There is a tendency for the animals to congregate, and usually several can be found at once.

Highlandensis, for the type locality.

North Carolina. Macon County: Highlands, 4000 feet, July 10, 1949. Dry Falls, 2 miles west of Highlands, 3400 feet, July 19, 1949. Wesser Bald, Nantahala Mountains, near Kyle, July 29, 1949.

Transylvania County: Rt. 64, 2 miles west of Lake Toxaway, July 15, 1949.

Tennessee. Sevier County: Chimneys Camp, Rt. 71 between Newfound Gap and Gatlinburg, July 28, 1949.

Delophon carolinum, new species

Plate 5, fig. 4

Type locality.—Satulah Mountain, Highlands, Macon County, North Carolina, at 4100 feet.

Type specimens.—Holotype and female allotype in the U. S. Nat. Mus., no.

1875; a topoparatype female in my personal collection and one in the Highlands Museum; July 20–24, 1949.

Diagnosis.—Similar to *D. georgianum* Chamberlin (1943: 14) but with fewer ocelli and differences in the male gonopods.

Description.—Width of male type, 1.2 mm., of allotype, 1.6 mm.; both 25 mm. in length.

Ocelli in 9 rows as in *georgianum* but the total number much reduced. Ocellus count in the type: 1, 2, 3, 4, 5, 6, 7, 8, 9 = 45 on the right side, and 2, 3, 4, 5, 6, 7, 8, 8 = 43 on the left.

Generally similar in structural characters to *Spirostrephon* but the poriferous keels are inconspicuous and not pyriform or swollen as in that genus.

Color blackish with a narrow middorsal line.

Male gonopods with the lower (or cephalic) terminal branch longer and larger than the other, a reversal of the condition in *georgianum.*

Relationships.—Close to *georgianum*, the only previously known member of the genus.

Ecology.—This species appears to be somewhat scarce at Highlands, where only a few were found despite searches which revealed large numbers of other species. It has been found there only in the oak-hickory woods on Satulah Mountain, in dry leaves and beneath pieces of bark. At Reed Creek Falls two specimens were found in the humus in a rhododendron thicket but on a well-drained slope.

North Carolina. Macon County: Satulah Mountain, Highlands, 4100 feet, July 20–24, 1949.
Georgia. Rabun County: Reed Creek Falls on Glade Mountain, July 27, 1949.

Family *Cleidogonidae*

Cleidogona jocassee, new species

Plate 7, figs. 15–18

Type locality.—Jocassee, Oconee County, South Carolina.

Type specimens.—Holotype and female allotype, U. S. Nat. Mus. no. 1876; ten topoparatypes in my personal collection, one in the Highlands Museum; all collected July 14, 1949.

Diagnosis.—A member of the *major* group of *Cleidogona, i.e.*, with the length 20 mm. or more; anterior division of the male gonopods straight and distally bifid; posterior division upright, simple, clavate. Distinct in the configuration of the gonopods and ninth male legs as illustrated.

Description of male holotype.—Length, 21 mm.; width at 7th segment, 2.4 mm.

Ocelli in a triangular patch, in 7 rows counting downward, from the front corner as follows: 1, 2, 3, 4, 5, 6, 6 = 27.

Configuration of body agreeing in all respects with the description given by Cook and Collins (1895: 42).

Color dorsally generally light brown or tan. Caudal margin of each tergite colorless. A small rounded whitish spot on each side of middorsal impressed

line, and a larger, oblong blotch on each side of the metatergites. Exposed portion of protergites darker brown along midline. Pleurites yellowish white. Legs uniformly white except terminal two joints, which are purplish. Front of head dark brown between the eyes, vertex marked with numerous fine parallel light lines. Three rounded light spots between the antennae. Clypeal region yellowish-white.

Gonopods large and prominent. Anterior division stout, nearly straight, distally bifid with the upper portion larger, somewhat expanded, finely setose; lower or anterior portion smaller, forming a thin, mesially directed lamina as seen in cephalic aspect. Posterior branch basally slender, straight, becoming expanded distally, notched just below the cephalic corner.

Ninth legs five-jointed, first and second subequal in length, the first globosely swollen basally, angularly produced distally; second slender over basal half, parallel, becoming swollen distally and abruptly contracted for insertion of tarsal joints. Latter subequal in size, third slightly the longest, the three combined shorter than half the length of the basal joint of the leg. The sternite is acutely produced upward laterad of insertion of leg.

Description of female allotype.—Length 22.4 mm.; width, 2.5 mm. Agreeing with male in structural features and in color, except the difference in body proportions.

Gonopods with the basal "receptacle" produced into two high, nearly straight, parallel-sided lobes as illustrated (the shape of these varying considerably with individuals). Valves quadrate in distal aspect, slightly larger cephalad, the upper surface strongly denticulate.

Relationships.—The closest relative of this form appears to be *Cleidogona major* Cook and Collins (1895: 47), known from Virginia and Maryland. *C. jocassee* is somewhat smaller and differs in gonopod characters, among which may be mentioned the much less swollen distal portion of the posterior branch and absence of the pronounced angular shoulder on the caudal margin of the anterior division. The terminal modification of the latter is also quite different. The sternite of the 9th pair of male legs is also acutely produced upward in *jocassee* and the second joint is much shorter in *major*. These differences, while significant, are only matters of degree, and the possibility that the two species intergrade cannot be precluded. Until such a time as extensive collections can be made in the Piedmont of North Carolina, however, I think it best to use full specific status for the present form.

Ecology.—This species was fairly abundant at the type locality, where it has a wide range of habitat types. Most of the Jocassee specimens were found in the leaf mold in a deep, shaded, cool ravine, very moist, with the forest cover chiefly yellow poplar, maple, hickory, and sweet gum. Undergrowth was chiefly rhododendron and laurel, and the ground was covered in many places with the interesting plant *Shortia galacifolia*. The pH of the humus was approximately 4.5 to 5. Other diplopods were scarce in the area, only *Cherokia georgiana* occurring in the same habitat. A few small scolopendrid and lithobid centipeds were observed. Specimens of the salamander *Plethodon clemsonae* were taken from the region as above characterized.

C. jocassee was later discovered to be common in the same sort of habitat elsewhere. *C. major*, at least where I have collected it in Piedmont Virginia, prefers hardwood forests and has not yet been found in ericaceous thickets.

North Carolina. Macon County: Highlands, chiefly Satulah Mountain, 4100 feet, July 9–30, 1949.
South Carolina. Oconee County: Jocassee, July 14, 1949.
Georgia. Rabun County: Reed Creek Falls on Glade Mountain, July 27, 1949.

Cleidogona margarita, new species

Plate 7, figs. 19–22

Type locality.—Chimneys Camp Area, Great Smoky Mountains National Park, Sevier County, Tennessee, on U. S. Rt. 71 between Newfound Gap and Gatlinburg.

Type specimens.— Holotype and female allotype, U. S. Nat. Mus. no. 1877; three topoparatypes also in the National Museum and one in the Park Headquarters collection at Gatlinburg, Tenn.

Diagnosis.— Distinct from all other known species as follows: ninth leg of males with a long, slender, clavate process from the distal end of the ventral face of the coxo-femur; receptacle of female genitalia, as seen in caudal aspect, produced into two upright lobes on each side as figured.

Description of male holotype.—Length, 18 mm.; width at 7th segment, 1.7 mm.

Ocelli in a triangular patch, arranged in 7 rows perpendicular to median line of the head, as follows: 1, 2, 3, 4, 5, 6, 7 = 28.

Configuration of body agreeing in all particulars with the description of the genus by Cook and Collins (1895: 42).

Color dorsally light brown, each segment with a broad dark gray band, this enclosing an oblong light spot on each side (extending as low as the lateral setigerous tubercule) and a small white dot near the median line, as usual in the genus. Sides and legs pale yellowish-white except tarsi which are brown. Sides of head and lateral light blotches finely reticulated with brown.

Gonopods of the *major* type, upright, nearly straight, slender, the anterior division distally bifid, the lower branch small, acuminate, the upper larger, somewhat flattened. Caudal margin of anterior gonopods as seen in lateral aspect abruptly produced caudad, forming an angular shoulder. Cephalic margin evenly lobed just below midlength. Posterior division simple, slender, distally clavate.

Ninth legs five-jointed, first slightly shorter than second, acutely lobed at base, distally produced into a long, slender, clavate branch. Second joint slightly bowed, thickest near midlength as illustrated. Basal two tarsi equal in size, expanded distally producing a somewhat moniliform aspect, terminal tarsal joint longer than basal two, slightly bacilliform, constricted beyond middle.

Other legs normal for the genus.

Description of female allotype.—Length, 17.5 mm.; width, 2 mm. Agreeing with male in most structural characters and in color.

Gynopods with the basal receptacle produced into four upright distinct lobes as illustrated. Valves quadrate in distal aspect, the upper surfaces conspicuously denticulate.

Relationships.—Although the male gonopods suggest affinity with *C. major* and *C. jocassee*, the nature of the ninth male legs and of the female genitalia precludes any close association of *margarita* with any presently known species. When our knowledge of the cleidogonid fauna is more complete, it may become desirable to set this species off in a separate genus.

Cook and Collins (1895: 21) mention "an aperture near the distal end of the second joint of the ninth legs of Cleidogona." I have not observed this in any of the available material but there appears to be an opening at the base of the first joint.

Ecology.—The type series was collected on a shady, north-facing hillside, with the dominant forest cover tulip poplar, magnolia, maple, and some hemlock. Undergrowth chiefly ericaceous shrubs. The millipeds were found under slabs of bark and in moist leaf mold, particularly around the bases of ferns whose dead fronds formed a sort of tent-like shelter.

Named for Mrs. Margaret Cannon Howell, in recognition of her interest in biological research at Highlands and in appreciation of many kindnesses.

Distribution.- Known only from the type locality.

Cleidogona inexpectata, new species

Plate 7, figs. 23–25

Type locality.—Chimneys Camp Area, Great Smoky Mountains National Park, Sevier County, Tennessee, on Rt. 71, between Newfound Gap and Gatlinburg.

Type specimens.—Male holotype and topoparatype, U. S. Nat. Mus., no. 1878; collected on July 28, 1949.

Diagnosis.—Similar to *jocassee* but with obvious differences in the male gonopods and ninth legs.

Description. -Length of holotype, 19.5 mm.; width, 1.6 mm. The structural characters are in all respects typical of other members of the genus Ocelli as in *jocassee*.

Anterior division of male gonopods rather stout, distally bifid with the cephalic portion forming a long slender mesially directed lamina, caudal portion slightly larger, finely setose. Caudal margin of anterior gonopods with a prominent knob just above midlength. Posterior gonopods simple, distally clavate.

Ninth legs of male with first joint bearing a raised circular projection at its base, also a rounded knob distally. Second joint much less swollen than usual for the genus.

Relationships. -Judged from the genitalia, the closest known relative of this species would be *C. major*.

Ecology.—Taken in association with *margarita* (*q.v.*).

Inexpectata, unsuspected, surprising. The two types were assumed to be *margarita*, of which a long series was obtained, and were recognized as distinct only by accident.

Distribution.—Known only from the type locality.

Order POLYDESMIDA

Family *Xystodesmidae*

Boraria carolina (Chamberlin). Bull. Univ. Utah **30**(2): 6, 1939.

Plate 6, fig. 14

Specimens representing this species were obtained at a number of localities, extending the known range widely. Previously reported from Soco Gap Falls, N. C., by Chamberlin (*op. cit.*) and from Mount Rogers, Virginia, by Hoffman (1949: 379); the distribution may now be said to coincide with the Southern Appalachian mountains from Grayson County, Virginia, south to Rabun County, Georgia. It is known from the Blue Ridge, and from the Iron, Balsam, and Nantahala ranges.

A species described as *Aporiaria fumans* by Prof. Chamberlin (1943: 37) from the Great Smokies may well be identical with *carolina*. The male gonopods are quite similar, the color patterns identical, and size about the same.

The dark, nearly black, color of the pleurites and anal valves immediately distinguish *Boraria* from all other genera of the *Xystodesmidae* known from eastern United States. Further generic characters are the short femoral spines, rather small, high keels, and small but definite tubercules on the posterior metatergites.

The species appears to be somewhat scarce on the Highlands Plateau, where I found only two specimens. Perhaps it prefers somewhat lower elevations, for it is abundant along the Chattooga River in southeastern Jackson County, N. C., where I obtained a number of specimens of both sexes under boards and in heaped up flood debris. The Highlands specimens were both taken in rather wet hemlock-rhododendron woods near small streams.

North Carolina. Macon County: Highlands, July 13, August 1, 1949. Wesser Bald, Nantahala Mountains, near Kyle, July 29, 1949.
Jackson County: Chattooga River near Grimshawes P. O., July 10, July 24, 1949.
Georgia. Rabun County: Glade Mountain at Reed Creek Falls, July 27, 1949.

Cherokia georgiana (Bollman). Proc. U. S. Nat. Mus. **11:** 344, 1888.

Plate 5, figs. 9–12

Fontaria georgiana Bollman, op. cit.
Fontaria tallulah Bollman, op. cit., p. 345.
Mimuloria ducilla Chamberlin, Bull. Univ. Utah **30**(2): 7, 1939.
Mimuloria furcifer Chamberlin, Ent. News **51:** 282–83, 1940.
Mimuloria georgiana Loomis, Bull. Mus. Comp. Zool. **92**(7): 402; Loomis, Psyche **51:** 173, 1944; Loomis and Hoffman, Proc. Biol. Soc. Wash. **61:** 52, 1948.
Dynoria parvior Chamberlin, Proc. Biol. Soc. Wash. **60:** 10, 1947.
Cherokia georgiana Chamberlin, Proc. Biol. Soc. Wash. **62:** 3, 1949.

This widespread species is probably the most abundant xystodesmid in the Southern Appalachians, and is represented by many specimens from almost

every station at which I collected. The material at hand shows considerable variation in characters, and some attention may profitably be paid to this subject.

Under the generic names *Mimuloria* and *Dynoria*, several species have been recently proposed in this genus by Prof. Chamberlin (1939, 1940, 1947). The first of these, *Mimuloria ducilla*, has previously been synonymized with *georgiana* by Loomis (1943: 402) who had examined Bollman's original types in the National Museum. *M. furcifer* was described from Asheville, N. C., and established on the basis of larger size, somewhat different coloration, and presence of a small denticulation on one side of the tibiotarsus of the male gonopod. The latest name, *parvior*, described as a species of *Dynoria* and contrasted with the type of that genus (*icana*), appears not to be different from *georgiana*.

Judged from available literature records and some museum specimens, *Cherokia* as a genus is well distributed, having been reported from west Florida, Alabama, Georgia, Tennessee, and North Carolina. It is now possible to add South Carolina. Apparently the northernmost locality for the genus is Asheville, N. C., and it is possible that the French Broad River forms a barrier of some effectivity to further northward dispersal.

In the 25 male specimens on hand from six areas in the southern Appalachians, I find a complete gradient in all of the diagnostic characters heretofore appealed to.

The gonopods are strikingly similar in all of the material. The presence or absence of an angulation on the lateral side of the tibiotarsus, utilized as a character of *furcifer*, cannot be relied upon, as the following tabulation will indicate.

Locality	*Present*	*Absent*
Western S. C. and northern Georgia	2	1
Highlands Plateau	4	5
Nantahala Mountains	3	—
Soco Gap Falls	1	6
Smoky Mountains	1	2

In the Highlands material there is complete transition in this character, and in several cases it is difficult to say whether or not an angle is present. The extremes in this series are shown on Plate 5, figures 9 and 10.

47 adult specimens measured show a variation in size from 6 to nearly 9 mm. in width. There is no correlation between locality and size range. Loomis and Hoffman (*op. cit.*) have previously noted the considerable width variation in this species.

Color pattern affords the best geographic variable, but even this breaks down in large series. The Soco Gap population, described as *ducilla*, generally has the median spots lunate and sometimes in contact with the lateral series, but this is found chiefly in females and some of the males have very small median dots. At Highlands there is a notable tendency for adults to have a broad orange band across the caudal margin of the tergites, this anomaly occurring in 9 of the 18 specimens before me.

In view of the preceding evaluation of characters, I cannot conclude other than that *georgiana* is a highly variable, wide-spread species in which incipient raciation is evident; and that *Cherokia* at present must be regarded as a monotypic genus.

The ecology of *georgiana*, as well as its distribution, points to the fact that it is an aggressive, highly successful, and probably fairly recent form. Occurring in some numbers at nearly every station visited, it is euryzonal as regards habitat, and has been found in evergreen stands, in oak-hickory forest, and in dense rhododendron thickets—in short, everywhere I have found millipeds in the area.

Large numbers of immature specimens are to be found during the summer months, the majority of those observed in the last week of July being in the penultimate instar and having the adult color fairly well developed. *Fontaria tallulah* Bollman (*op. cit.*) was based on one of these forms, in which the keels are frequently red instead of yellow. No specimens have been found in copulation, this apparently taking place in a definite spring mating season as opposed to the summer-long period of certain other millipeds.

A female was dug up in deep leaf mold on July 23 at Highlands apparently just after she had commenced to deposit eggs. About 50–60 were in the cluster. These doubtless hatch before winter and the young mature the following summer.

An interesting situation has been observed in connection with the female genitalia. In these the outer valve is flattened and much larger than the inner, and no trace of a basal element (the receptacle) can be found. The latter is much reduced in certain genera (*e.g*, *Nannaria*) but has not heretofore been found wanting. The disparity in sizes of the valves suggests relationships with *Zinaria*, as does the nature of the sternites and male gonopods. The genitalia are illustrated.

North Carolina. Macon County: Highlands, 3900–4200 feet, July 9–31, 1949. Wesser Bald, Nantahala Mountains, near Kyle, 2500 feet, July 29, 1949.
Jackson County: Chattooga River at Grimshawes P. O., July 10, 1949. Soco Gap Falls, Balsam Mountains, between Cherokee and Waynesville on Rt. 23, July 28, 1949 (topotypes of *ducilla*).
South Carolina. Oconee County: Jocassee, July 15, 1949.
Pickens County: Sassafras Mountain, Rt. 178, 15 miles NW of Pickens, July 15, 1949.
Georgia. Rabun County. Glade Mountain, about 5–7 miles south of Highlands, July 27, 1949.
Habersham County: Tallulah Gorge, July 18, 1949 (topotypes of *tallulah*).
Tennessee. Sevier County: Great Smoky Mountains National Park, near Chimneys, July 28, 1949.

Howellaria, new genus

Generotype.—*Aporiaria deturkiana* Causey (1942: 169).

Diagnosis.—Composed of head and 20 segments. Pore formula normal, pores opening dorsally on posterior third of keels. Latter directed conspicuously ventrad, dorsum highly arched. Keels with a notch on the caudal margin at point of insertion on tergite (suggesting the condition found in some cyclodesmids).

Tergites smooth and shining. Sternites flat, median constriction not obvious, caudal margin not lobed or spined. Prefemora caudad of gonopods with large, slightly curved spines. Femora spined as usual in the family. Male gonopods similar to those of *Boraria* (type, *carolina*) but the numerous other structural differences preclude any close association of the two genera. *Howellaria deturkiana* differs trenchantly from the forms of *Boraria* in (1) the highly arched, smooth dorsum (nearly flat and definitely wrinkled in *Boraria*), (2) the presence of large spines on the prefemora of the walking legs, (3) the color of the pleurites and anal valves being yellowish-tan instead of black, and (4) the terminal tarsal joint being conspicuously longer than the basal two, and much longer than femur. The general facies of the two genera are decidedly different. Plate 6 illustrates the differences in the 12th segment.

A further discussion of the relationships of the genus is planned for inclusion in a forthcoming account of the Xystodesmidae.

It gives me a great deal of pleasure to be able to name this unusual genus for Prof. Thelma Howell, in recognition of her interest in promoting knowledge of the Highlands fauna, and in appreciation of many kindnesses which served to make my work at Highlands the more enjoyable.

Howellaria deturkiana (Causey). Ent. News **53:** 169, 1942.

Plate 5, figs. 7, 8; plate 6, fig. 13

A single male topotype was obtained by digging in wet humus in a rhododendron thicket at Highlands. It agrees in every respect with Causey's description. The gonopods are figured herewith in two aspects.

North Carolina. Macon County: Highlands, edge of Lake Ravenel, July 13, 1949.

Nannaria austricola, new species

Plate 8, figs. 26, 27

Type locality.—Satulah Mountain, Highlands, Macon County, North Carolina.

Type specimen.—Adult female holotype, U. S. Nat. Mus. no. 1879, collected on July 26, 1949.

Diagnosis.—Immediately distinguished from all known species of *Nannaria* by the enormous spines of the femora of the walking legs. These are much longer than the femur itself and nearly the length of the tibia. The gynopods are probably also of specific diagnostic value.

Description.—A rather small species. Length of type, 22 mm.; width, 4 mm. Structural features in general as described for various other members of the genus (e.g. *morrisoni* Hoffman, 1948: 348).

Color dark olive-gray as usual in the genus, edges of collum and caudolateral halves of keels pink. Underparts white.

Typical ambulatory leg from midbody as illustrated.

Gynopods with valves subequal in size, elongate, larger and proximally lobed

toward the attached end (insertion of oviduct), the upper edges of the valves shallowly scalloped; inner portions of valves excavate, forming a concavity with the suture along its middle. Receptacle much reduced, consisting merely of a small, subtriangular plate, loosely connected to the valves. Gonopodal aperture without special raised marginal flanges.

Relationships.—Since all previous workers have without exception ignored the taxonomic characters afforded by female genitalia it is at present very difficult to predict just where the affinities of this species lie. As far as known forms go, *N. morrisoni* of the Virginia Blue Ridge has the femoral spines approaching the size represented in *austricola* and the two species are about the same overall size.

In the material of *Nannaria* available to me, I find that the female genitalia provide excellent diagnostic features, and should by all means be utilized by milliped workers. A study of *Nannaria* is in preparation, in connection with which material of 17 species has been studied.

Ecology.—The single specimen was found in loose leaves in a dense, wet rhododendron thicket edging a small swift stream. This is precisely the conditions under which I have found most of the Nannariae that I have collected. An extended search over the immediate vicinity, as well as in other similar areas, resulted in the discovery of numerous immature specimens but no additional adults.

The name *austricola* is given in recognition of the fact that this is the southernmost member of the genus. In the lowlands of the Southeast, *Nannaria* is replaced by the closely related groups *Eploria* and *Dicellarius*.

Distribution.- Known only from the type locality.

Nannaria scutellaria Causey. Ent. News **53:** 168, 1942.

Three topotypes were obtained in the Smokies in the area described above under *Cleidogona margarita*. They agree in all respects with the original description.

Tennessee. Sevier County: Chimneys Camp Area, Rt. 71, between Newfound Gap and Gatlinburg, Great Smoky Mountains National Park, July 28, 1949.

Sigiria rubromarginata (Bollman). Proc. U. S. Nat. Mus. **10:** 622, 1887.

Fontaria rubromarginata Bollman, *op. cit.*

Sigiria scorpio Chamberlin, Bull. Univ. Utah **30**(2): 9, 1939.

I have long suspected that Chamberlin's name *scorpio* actually applied to Bollman's species, especially since the former has been reported (Chamberlin, 1940: 56) from Soco Gap, N. C., only about 10 miles from the type locality of *rubromarginata*; and since the descriptions of the two match very closely.

On August 3rd I collected at Balsam, N. C., and was fortunate in obtaining three topotypical specimens, the gonopods of which are identical with those figured for *scorpio*. The animals were found in a very thin layer of moist leaves on a loose dirt bank, adjacent to the stream draining south from Balsam. The forest cover was yellow poplar and maple.

It is now possible to record this species from three localities, cited below. The range suggests a general occupancy of the northern part of the Great Smokies and extension eastward therefrom on such satellites as the Balsams, and perhaps the Cowees.

North Carolina. Jackson County: Balsam (Bollman, *op. cit.*), also a male and two females, August 3, 1949. Soco Gap Falls, April 29, 1939 (Chamberlin, 1940: 56).

Madison County: between Hot Springs and Paint Rock, August 7, 1910, R. V. Chamberlin (types of *S. scorpio*).

Sigmoria nigrescens, new species

Plate 8, figs. 28–32

Type locality.—Sassafras Mountain, on U. S. Rt. 178, one mile west of the intersection with S. C. Rt. 288, Pickens County, South Carolina.

Type specimens.—Male type and female allotype, U. S. Nat. Mus. no. 1880; a male topoparatype in my personal collection; July 15, 1949.

Diagnosis.—Similar to *S. divergens* Chamberlin (1939: 8) in configuration of male gonopods, differing from that species and others in lacking all traces of red or yellow pigment. Dorsum uniform bluish-black, the edges of the tergites narrowly unpigmented.

Description of male holotype.—Length, 43 mm.; width, 10.5 mm.

Structure as usual for this genus. Tergites rather flattened, keels wide, continuing slope of dorsum; finely coriaceous; prozonites smooth. Repugnatorial pores dorsal in position, in an ellipsoid swelling. Caudolateral corners of keels posterior to those of fifth segment becoming increasingly produced.

Sternites nearly flat, not produced into lobes or spines at bases of legs. Latter relatively long and slender, the prefemora with small ventral spines; femora with acute ventrodistal spine as usual. Tibiae long and slender. Terminal tarsal joint nearly as long as basal two combined.

Sternites anterior to gonopods without special lobes or processes.

Gonopods in a large rounded-ovoid aperture, without raised edges. Femoral portion massive, densely setose, with a small hook-like lateral femoral process. Tibiotarsus heavy, sigmoidally curved in a cephalolateral direction, its median side not produced into a thin broad lobe as in *latior* and related species; distal portion becoming flattened and somewhat twisted as shown in the drawings.

Dorsal color uniform bluish-black, with a very thin margin to the metatergites colorless. Sternites yellowish-white, legs white, lightly reticulated with black. A thin black mark on the pleurites beneath the keels. Antennae brown. First pair of legs white.

Description of female allotype.—Length, 39 mm.; width, 10 mm. Similar in most respects to male, differing only in proportions of body, greater arch of dorsum, etc.

Gynopods large, their aperture behind second pair of legs without raised marginal flange. Receptacle broadly horse-shoe shaped, the lateral caudal projections triangular in lateral aspect as illustrated. Both valves with the median dorsal portion excavated, the surface with conspicuous cross-ridges. Caudal

portion of each valve produced into a conspicuous knob, these in contact mesially as seen in distal aspect.

Relationships.—Obviously the closest relative of this form is *Sigmoria divergens* Chamberlin, described from Landrum, Spartanburg County, S. C., a locality at the eastern edge of the Blue Ridge escarpment and about 35 miles northeast of the type locality of *nigrescens*. The gonopods of the two are similar, but seem to be much shorter and heavier in *nigrescens*, also the color pattern of the latter is unique for the genus and probably for the family as well. My original surmise that the specimens had only recently molted was not borne out, for they were kept alive long enough for any incipient red pigment to manifest itself in the adult pattern.

These two species, with possibly *S. mimetica* (Chamberlin, 1918: 29) from central Tennessee, form a distinct subgeneric group based on similarity of the male gonopods. It is also interesting to note that the three occupy more or less peripheral positions on the general range of the genus. A further investigation, including a study of the female genitalia, should be of much value. Unfortunately, published drawings of the known Sigmorias show the male gonopods in such a diversity of aspects that comparisons cannot be accurately made.

Regarding the use of male genitalia as specific characters, it is of interest to record here some remarks on the subject by two careful American workers (Cook and Collins, 1895: 31):

"Dissection is an absolute necessity in studying the genitalia of the smaller forms, and the greatest caution must be exercised for the different views of the same irregularly shaped genitalium will look like entirely different structures. . . . This method has the further advantage of allowing corresponding parts to be viewed at the same angle, so that fictitious differences are not multiplied. . . . Descriptions of genitalia are nearly worthless without diagrams to aid in their interpretation."

It is a matter of some regret that later American workers have never paid much attention to such reasonable admonition.

Ecology.—The type specimens were found in a deep, narrow, moist ravine on the side of Sassafras Mountain, with the dominant forest cover tulip poplar, hickory, maple, and a few oaks. Near the stream were many shrubs of rhododendron. The millipeds were found in leaf mold along a path, where the debris had been piled up by water.

The specific name refers to the black color.

Distribution – Known only from the type locality.

Sigmoria, species incertis

A single female of this genus obtained in the Nantahalas of western Macon Co., N. C., seems to be undescribed, but may actually be Chamberlin's *S. stenogon* (1942: 5). Although an extended search was made in the vicinity, no additional specimens could be found, and I feel it unwise to propose a new name in the absence of males. The color pattern is one of the most attractive I have seen in millipeds, and a description of the color from life may be of interest.

"Prozonites and front margin of metazonites shining black, rear two-thirds of metazonite light pearl gray as is tip of anal segment and rear edge of collum; entire dorsal surface of keels and front edge of collum bright vermilion. Underparts whitish, legs becoming pink distally. Antennae brown." (Field notes.)

Chamberlin (*op. cit.*) says of *stenogon*: "The preserved specimens have the tergites anteriorly brown with the caudal half and the keels yellow . . . etc."

North Carolina. Macon County: Nantahala Mountains, west side of Wesser Bald on Otter Creek, near Kyle, July 29, 1949. One female in humus in rhododendron thicket near creek.

Family *Polydesmidae*

Dixidesmus branneri (Bollman). Proc. U. S. Nat. Mus. **10:** 620, 1887.

Polydesmus branneri Bollman, *op. cit.*

Polydesmus conlatus Chamberlin, Proc. Biol. Soc. Washington **56:** 36, 1943.

A very characteristic and abundant species of the Great Smokies and other adjacent mountains, *branneri* extends north into Virginia as far as the latitude of Charlottesville and Hot Springs. It is, in the northern part of its range, definitely a montane form and restricted to high or cool habitats. *Branneri*, or a form of it, apparently occurs south as far as northern Florida (Gainesville) and elsewhere along the Gulf Coast. Floridian material is much smaller than Appalachian, but the male gonopods are identical. Chamberlin's description of *conlatus* (*supra*) recorded it from southern Georgia at Thomasville.

During the course of my Highlands work I obtained only a few specimens, in the Smokies, and these add nothing to the range of the species which has previously been recorded from Newfound Gap.

Tennessee. Sevier County: Chimneys Camp on Rt. 71 between Newfound Gap and Gatlinburg, several males taken July 28, 1949, in leaves on a shady north-facing hillside.

Dixidesmus tallulanus Chamberlin. Bull. Univ. Utah **34**(6): 19, 1943.

Apparently the dominant and only large polydesmid species on the Highlands Plateau. Great numbers of immature specimens were found during July, chiefly in oak-hickory forest, but the only mature males were obtained on July 22 and August 2.

D. tallulanus has previously been recorded only from several stations in Rabun County, Georgia; the following records provide the second locality for the species and the first record for it in North Carolina.

North Carolina. Macon County: Highlands, generally distributed and observed during July, 1949; adult male taken on south side Satulah Mountain, August 2, 1949. Dry Falls, 3 miles west of Highlands on Rt. 64, July 22, 1949 (J. M. Valentine).

Scytonotus granulatus (Say). Jour. Acad. Nat. Sci. Philadelphia **2:** 107, 1821.

Large numbers of immature specimens found at Highlands. This species does not mature until October or November and it is extremely difficult to collect

adults in the summer. My identification is wholly tentative, the Highlands population may be *S. virginicus* or an undescribed species.

North Carolina. Macon County: Highlands, generally distributed and observed during July, 1949.

Order SPIROBOLIDA

Family *Spirobolidae*

Spirobolus dolleyi (Loomis). Bull. Mus. Comp. Zool. **92**(7): 398, 1943.

The animal at hand presents some interesting and perplexing problems. My identification above is only provisional, the specimen merely being more like *dolleyi* than like *marginatus* or *orophilus*. In the present state of our knowledge, I find it extremely difficult ever to be really sure about some of the Spiroboli. A thorough revision of the genus is much needed here, as with other groups.

S. dolleyi has been reported from Mississippi and Alabama by Loomis (*op. cit.*), and I have some material from southwest Virginia that fits the description perfectly. The eastern forms may eventually all turn out to be subspecies of *marginatus*. The ranges would appear to be vicarious.

My adult male was found crawling across a trail through a rhododendron thicket and brought in just before my departure. The scarcity of spirobolids at Highlands and elsewhere during 1949 is somewhat remarkable, considering the usual abundance of the creatures.

North Carolina. Macon County: Highlands, Rhododendron Trail, August 1, 1949 (R. E. Gordon)

Order JULIDA

Family *Paraiulidae*

Ptyoiulus, species incertis

This form was rather abundant but no mature specimens of either sex could be found. Since it could equally well be any of the three species known from eastern United States (*pennsylvanicus*, *coveanus*, *georgiensis*) I hesitate to make a tentative specific determination.

The millipeds were almost altogether found in well-drained deciduous woods, in and around Highlands.

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EXPLANATION OF PLATES

PLATE 5

Fig. 1, 2. *Onomeris australora*, n. sp. 1, nineteenth male legs, ventral view, 2, female genitalia, caudal view.

Fig. 3. *Striaria zygoleuca*, n. sp. Left gonopod of male, caudal view.

Fig. 4. *Delophon carolinum* n. sp. Right gonopod of male, *in situ*, lateral view.

Fig. 5, 6. *Spirostrephon highlandensis* n. sp. 5, male gonopod in lateral aspect. 6, left male gonopod, caudal view.

Fig. 7, 8. *Howellaria deturkiana* (Causey). 7, left male gonopod, cephalic view. 8, the same, mesial view.

Fig. 9–12. *Cherokia georgiana* (Bollman). 9, 10, cephalic views of the tibiotarsi of the

gonopods of two males from Highlands, showing extremes in variation of the subterminal tooth. 11, lateral aspect of female gynopod. 12, distal aspect of same.

PLATE 6

Fig. 13. *Howellaria deturkiana* (Causey). Lateral view of two midbody segments, legs not shown.

Fig. 14. *Boraria carolina* (Chamberlin). Lateral view of two midbody segments, legs not shown.

PLATE 7

Fig. 15–18. *Cleidogona jocassee* n. sp. 15, lateral view of male gonopods. 16, cephalic view of same. 17, ninth male leg and part of sternite. 18, female gynopods, caudal view.

Fig. 19–22. *Cleidogona margarita* n. sp. 19, lateral view of male gonopods. 20, cephalic view of same. 21, ninth male leg. 22, female gynopods, caudal view.

Fig. 23–25. *Cleidogona inexpectata* n. sp. 23, lateral view of male gonopods. 24, cephalic view of same. 25, ninth male leg.

PLATE 8

Fig. 26, 27. *Nannaria austricola*, n. sp. 26, leg from midbody segment to show greatly developed femoral spine. 27, lateral view of female gynopod.

Fig. 28–32. *Sigmoria nigrescens*, n. sp. 28, left male gonopod, cephalic view. 29, the same, mesial view. 30, the same, caudal view of tibiotarsus. 31, lateral view of gynopod. 32, distal view of gynopod.

PLATE 5

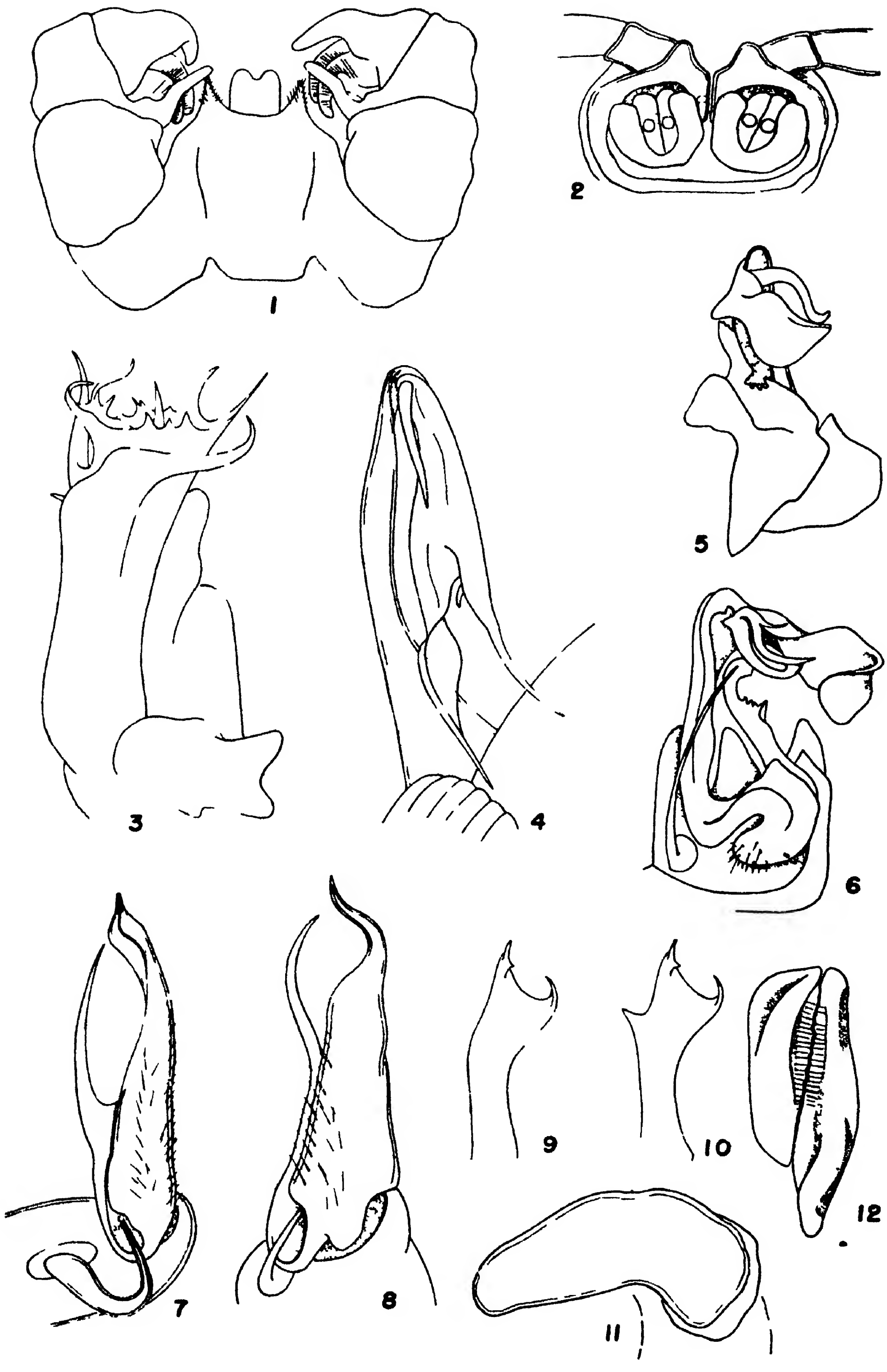
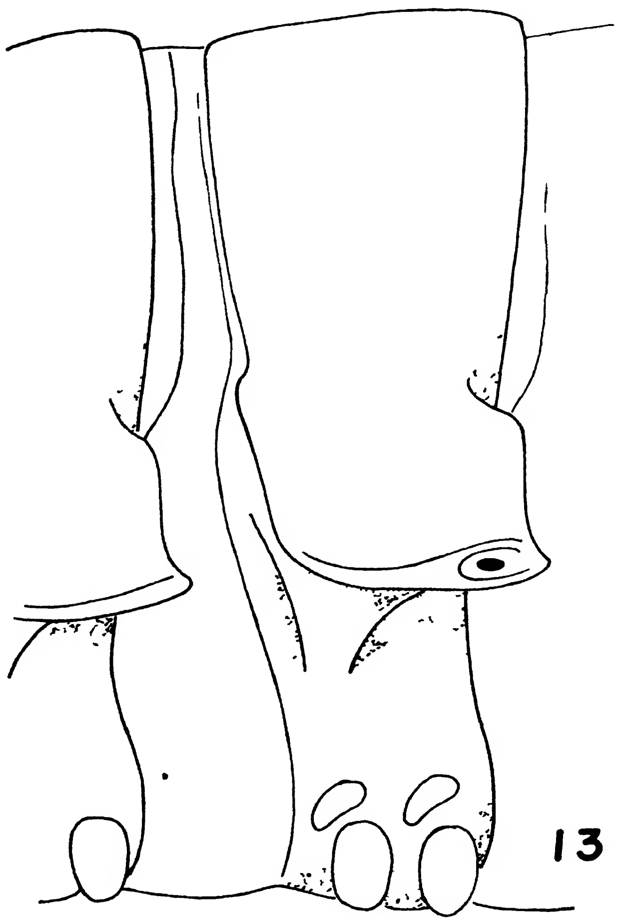


PLATE 6



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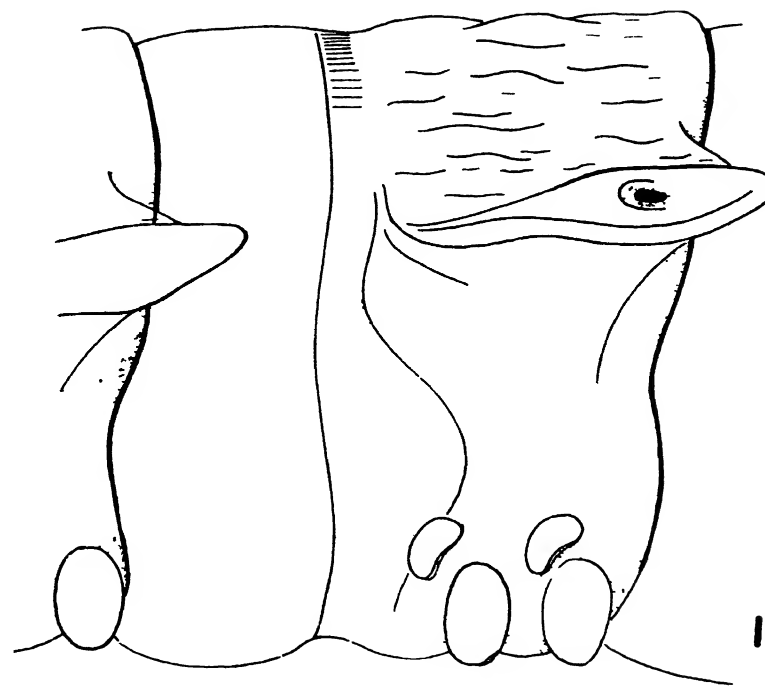

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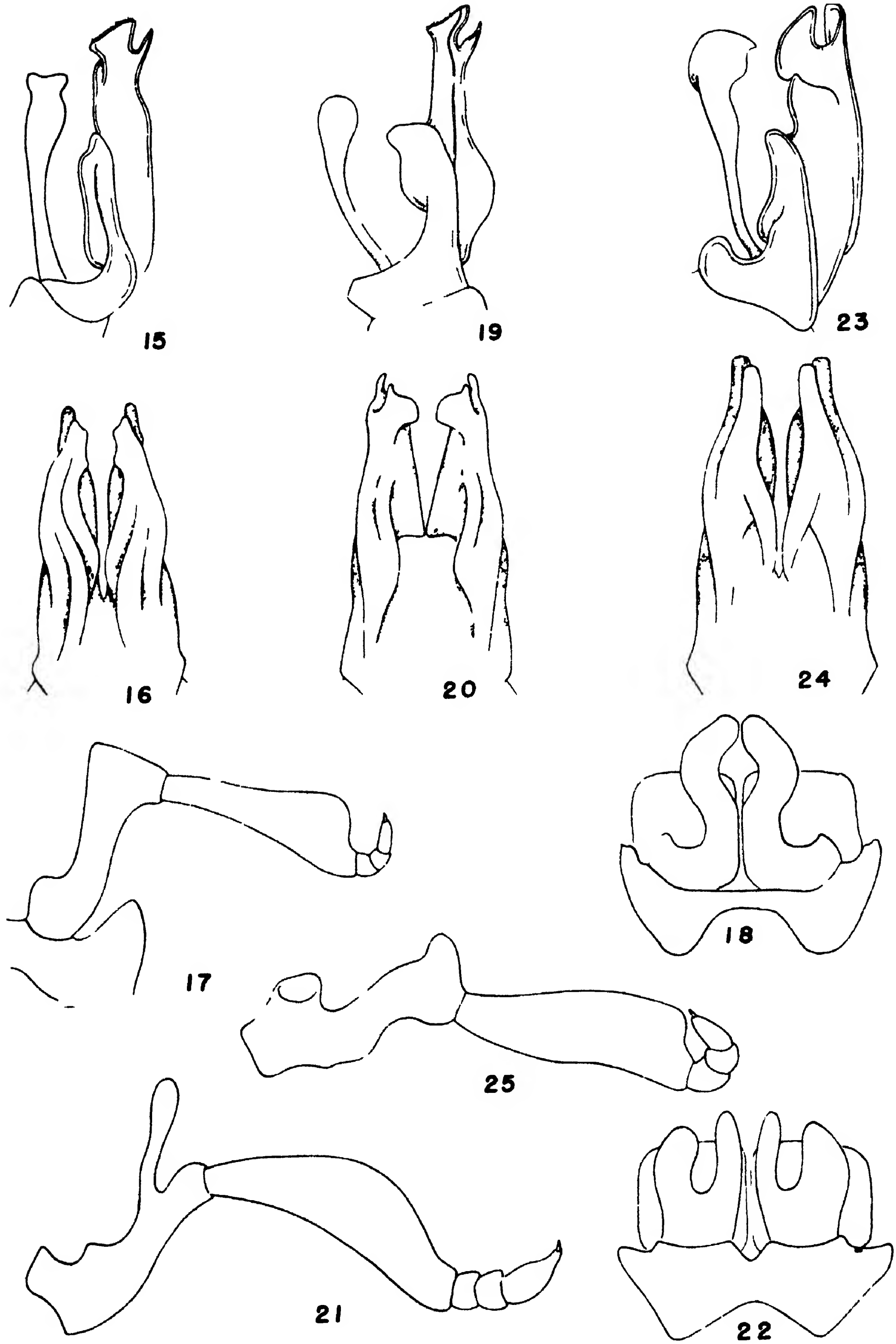
PLATE 7



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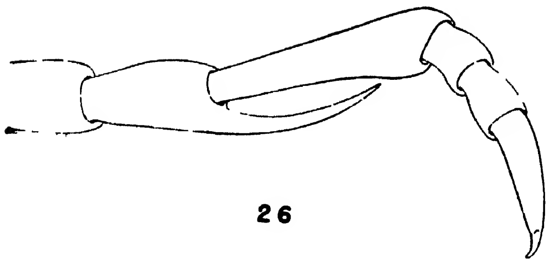
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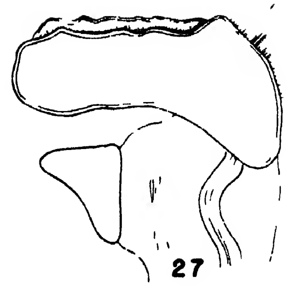
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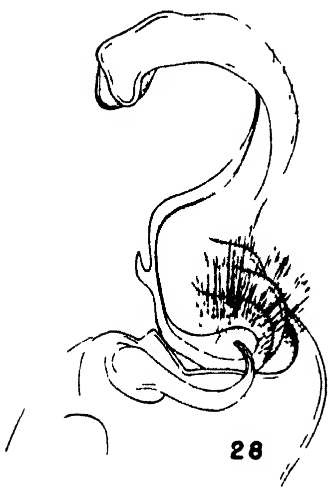
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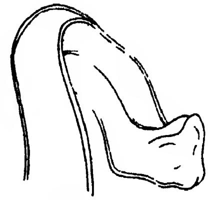
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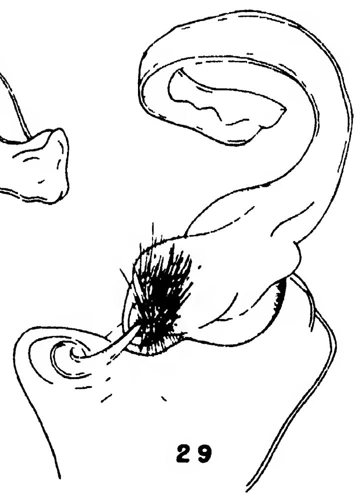
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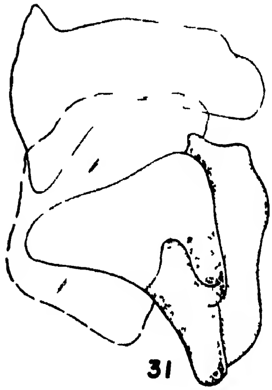
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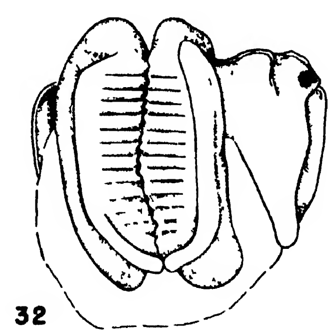
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STUDIES ON MYCOSPHAERELLA ROSIGENA[1]

By D. E. Ellis and C. N. Clayton

Plate 9

Mycosphaerella rosigena (E. & E.) Lindau was described on rose leaves from Louisiana (Ellis and Everhart, 1887; Saccardo, 1891). Although this fungus has been reported from a number of countries, comparatively little is known about its life history and pathogenicity. Available reports indicate that it is rather widely distributed on cultivated roses (*Rosa* spp.) and that at times it is associated with a leaf spot of considerable economic importance. In the United States the fungus has been reported from Louisiana, New Jersey (Halsted, 1894), New York (Stewart, 1910), Maryland (Weiss, 1942), Ohio[2], Tennessee[2], and North Carolina (Ellis and Clayton, 1948). It has been found in Porto Rico (Weiss, 1942), Panama (Weiss, 1942), Cuba (Bruner, 1921), Trinidad (Stevens, 1930), the Dominican Republic (Ciferri and Fragoso, 1926), Brazil (Averna-Sacca, 1926), Australia (Grieve, 1932), India (Sydow and Butler, 1911), Malta (Anon., 1913), and China (Ling, 1948). A variety, *M. rosigena* var. *madagascariensis*, was reported from Madagascar (Bouriquet, 1946). Also according to a letter from Freeman Weiss[2], there are references to its occurrence in Argentina, Bermuda, Venezuela, Ceylon, Italy, and Spain.

In the fall of 1947 *M. rosigena* was found consistently associated with a severe leaf spot defoliation of greenhouse roses (Better Times and Briarcliff varieties) in Raleigh, North Carolina. Brief descriptions of the symptoms of the disease and the cultural characteristics of the fungus were reported (Ellis and Clayton, 1948). Further observations on the physiology, morphology, and pathogenicity of the organism are given below.

SYMPTOMS

The symptoms observed in North Carolina agree in most respects with those given by Stewart (1910) who described the disease on greenhouse roses in New York. The grayish-brown leaf spot constitutes the most characteristic symptom (Pl. 9, fig. 1). A typical spot, is somewhat irregular in outline and has a necrotic center surrounded by a purple border. The spots range from about 0.5 to 5 mm. in diameter. The tiny perithecia of *M. rosigena* are borne in great numbers on necrotic areas of both leaf surfaces. Young spots not yet necrotic are purple in color and range in size from flecks just visible to the naked eye to about 3 mm. in diameter. Frequently, when these spots are very numerous, chlorosis develops in the areas between them and the leaflets abscise before they become necrotic.

[1] Contribution from the Plant Pathology Section, Department of Botany, North Carolina Agricultural Experiment Station, Raleigh, North Carolina. Published with the approval of the Director as Paper No. 338 of the Journal Series.

[2] Records on file with Division of Mycology and Disease Survey, Beltsville, Maryland, according to correspondence from Dr. Freeman Weiss.

The disease is apparently confined to the older, fully expanded leaves. Lesions occur abundantly on leaves below excised flower stalks, but none were observed on leaves of shoots that grew from axillary buds just below the most recently cut flower stalks. Severe defoliation sometimes resulting in a loss of 90 per cent of the foliage is associated with the disease.

PATHOGENICITY

M. rosigena was readily isolated from the very small non-necrotic (no visible necrosis) purple lesions as well as from large necrotic spots. In Table 1 are given the results of one series of isolations on potato-dextrose agar. Small pieces of affected tissue were cut from leaves, dipped in either a 1–1000 aqueous solution of mercuric chloride for 30 seconds or in a 0.5 per cent aqueous solution of sodium hypochlorite for 1 minute, washed in 4 changes of sterile distilled

TABLE 1

Number of colonies of M. rosigena *and other organisms isolated from rose leaflet lesions of various sizes*

DIAMETER OF LESIONS	SURFACE DISINFECTANT USED	NUMBER OF PLATINGS	NUMBER OF PLATINGS YIELDING	
			M. rosigena	Other fungi and bacteria
1 mm. or less (not necrotic	Mercuric chloride	24	17	2
	Chlorine	24	20	4
1 to 3 mm. (not necrotic)	Mercuric chloride	24	15	3
	Chlorine	24	20	18
3 to 12 mm. (necrotic)	Mercuric chloride	24	17	5
	Chlorine	24	22	14
Totals..		144	111 (77%)	46

water, and transferred aseptically to potato-dextrose agar in Petri dishes which were kept at about 25°C. for 6 to 10 days.

The fact that *M. rosigena* was isolated about as consistently from both groups of small, purple, non-necrotic lesions as from the older necrotic spots bearing perithecia indicated strongly that the fungus was parasitic.

M. rosigena is generally considered to be pathogenic and has consistently been reported as occurring in necrotic spots on living leaves. However, no record of inoculation tests has been found.

Inoculations with pure cultures of the organism were made on young Better Times rose plants in a greenhouse at Raleigh, North Carolina, in 1948. Cultures about a month old were macerated in a Waring blender and atomized onto the leaves. The inoculated plants, together with non-inoculated control plants, were placed in a moist chamber for 48 hours and then removed to the greenhouse bench. About two months after inoculation sparse infection appeared on four of the eight plants inoculated. Perithecia with mature ascospores of *M.*

rosigena later developed on many of the affected leaves. The fungus was recovered in culture. No symptoms of the disease developed on four non-inoculated plants used as controls. In presenting the positive results of this inoculation test it is recognized that they are not conclusive and that additional work will be necessary to explain fully the pathogenesis of *M. rosigena.*

THE FUNGUS

Perithecia and asci of *M. rosigena* are shown in Plate 9, figs. 2 and 3. The fungus in North Carolina was found to conform in all important aspects to the original description (Ellis and Everhart, 1887) and to the drawings of Schwarze (1917). In comparing it with a portion from the type collection[3] and with *M. rosicola* B. H. Davis[4], it was found to conform to the former and differed from the latter as expected from the original descriptions of the two species (Ellis and Everhart, 1887; Davis, 1938).

Perithecia of *M. rosigena* occur abundantly on necrotic lesions on living leaves as well as on abscised dead leaves. Necrotic spots barely visible to the

TABLE 2

Relative abundance of perithecia of M. rosigena *on dorsal and ventral surfaces of necrotic lesions of various sizes*

LEAF SURFACE	NUMBER OF PERITHECIA PER SQ. MM. ON LEAF LESIONS OF STATED DIAMETERS		
	0–0.5 mm.	0.5–1.5 mm.	1.5–5.0 mm.
Dorsal	9	24	37
Ventral	11	17	27

naked eye may bear numerous perithecia on both leaf surfaces. Results of perithecial counts on dorsal and ventral surfaces of affected leaflets are shown in Table 2. The averages are based on perithecial counts in 20 lesions for each of the first two categories and 10 for the third one.

No record has been found of *M. rosigena* having been cultured. Experiments showed that it grew well on the following agar media which were prepared according to standard formulae excepting as indicated: potato-dextrose, potato-dextrose plus 0.1 per cent asparagin, bean, corn-meal, prune, rose leaf[5], rose leaf plus 2 per cent dextrose, and 2 per cent dextrose. After 33 days at 25°C. average colony diameters for 5 plates of each of the above media were 16.3, 15.3, 21.8, 13.5, 15.8, 35.5, 17.5, and 17.2 mm., respectively. These figures, however, do not indicate relative total growth as the colonies tended to be much more raised on some media than others. Preliminary studies indicate that the optimum temperature for growth in culture was between 20° and 30°C. Only a trace of growth occurred at 5°C. and none at 35°C.

[3] Loaned by Dr. John A. Stevenson.

[4] Loaned by Dr. L. M. Massey.

[5] 135 gms. dried rose leaves steeped in 500 ml. water at 90°C. for 1½ hours; decanted, 20 gms. agar added, and water added to bring volume to 1000 ml.

The colonies are olive-gray on potato-dextrose agar, have irregular margins, and form raised mounds of hard stroma-like tissue (Pl. 9, fig. 4) in which numerous perithecia are embedded. Immature perithecia were formed within 14 days and a few contained asci and ascospores after 21 days. Although immature perithecia were found within 26 days on all of the above named media except rose leaf agar, they had reached a mature condition only on potato-dextrose, potato-dextrose plus asparagin, and dextrose agars. They were most abundant on potato-dextrose agar. No asexual spores were observed.

SUMMARY

Mycosphaerella rosigena on cultivated roses is widely distributed in tropical and subtropical countries of the world and occurs in greenhouses in certain temperate regions of the United States.

The fungus was associated with a severe leaf spot of Better Times and Briarcliff roses growing in a greenhouse at Raleigh, North Carolina, in 1947.

The fungus was readily and consistently isolated from the tiny, purple, non-necrotic leaf spots.

In an inoculation test sparse infection and typical leaf spots containing perithecia and ascospores were obtained on 4 of 8 inoculated Better Times rose plants. Four control plants remained healthy.

M. rosigena was isolated in pure culture and grew well on several agar media. At about 25°C., on potato-dextrose agar, olive-gray raised colonies were formed in which numerous perithecia occurred after 14 days and mature ascospores were produced after 21 days.

Counts showed that perithecia occur abundantly in necrotic leaf spots on both leaf surfaces.

No asexual stage of the fungus was found in culture or on rose leaves.

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EXPLANATION OF PLATE 9

Mycosphaerella rosigena

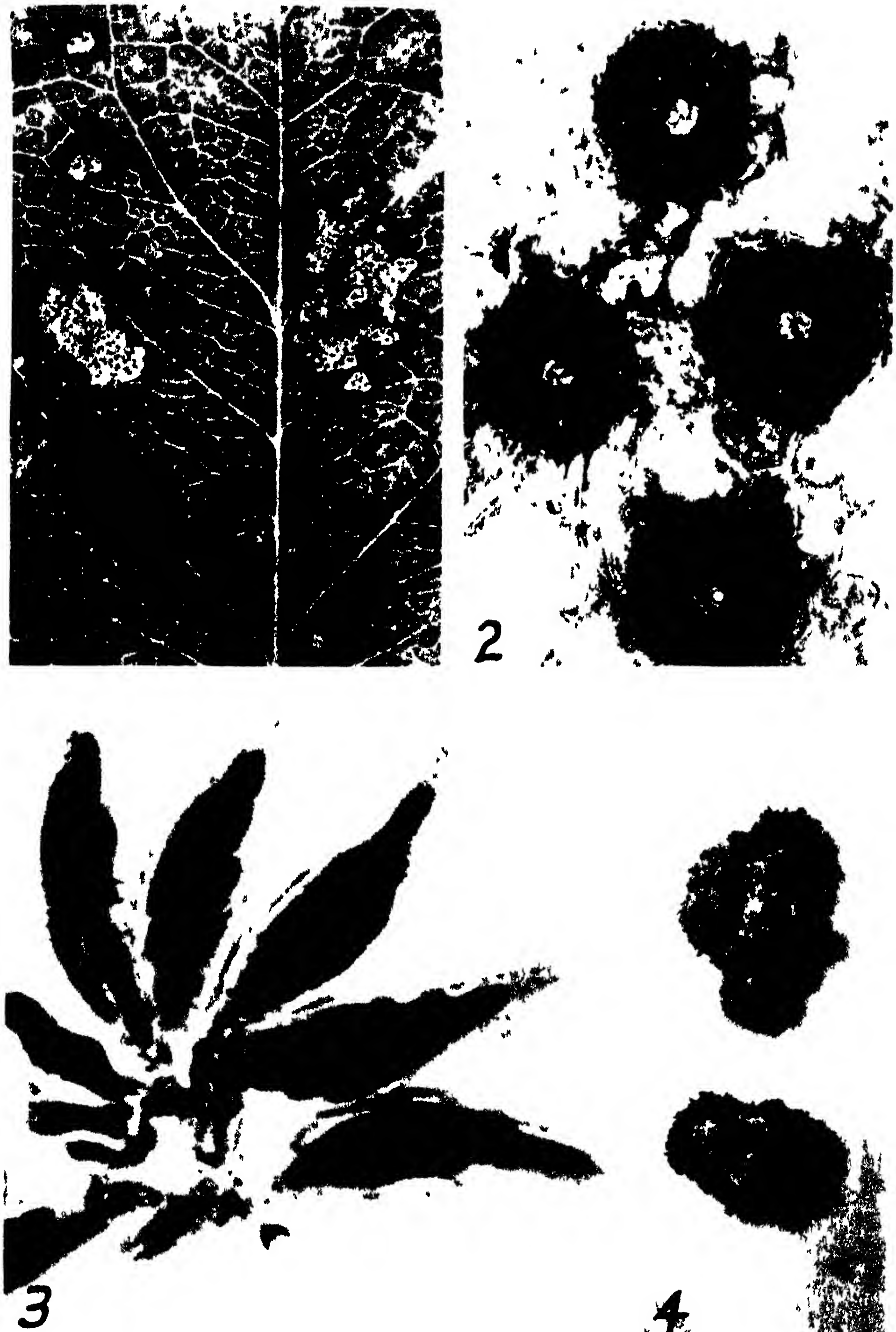
FIG. 1. Enlarged portion of Better Times rose leaflet with typical leaf spots containing numerous small perithecia. × 3.5 (approximately).

FIG. 2. Portion of cleared rose leaflet containing perithecia. × 350

FIG. 3. Part of contents of a perithecium showing asci with ascospores stained with cotton blue. × 1666.

FIG. 4. Thirty-day-old colonies on potato-dextrose agar. × 1 25

PLATE 9



BOPYRID ISOPODS FROM THE COAST OF NORTH CAROLINA

By A. S. Pearse

Department of Zoology, Duke University
Durham, North Carolina

During the summer of 1949 collections were made from the reefs off the Carolina coast. Two species of parasitic isopods were found, one of which appears to be new. These and their hosts have been deposited in the United States National Museum.

Thanks are due to Dr. Louis G. Williams, who dived to depths of 12 to 50 feet. The United States Fish and Wildlife Service furnished working space at their Beaufort Laboratory, where Clinton Atkinson and Vance Fulford did everything possible to help the work.

Bopyro choprae Pearse

Figs. 1, 2

Two pairs were collected on August 8 from the Black Rocks six miles offshore at a depth of 45 feet, from the gill chambers of snapping shrimps, *Synalpheus longicarpus* Herrick and *S. minus* (Say). These agree with the descriptions in my 1932 paper, except that the terminal segments of the abdomens of the females (Figs. 1, 2) show some variation. This may be due to age or the size of the host, as the first host mentioned was much smaller than the other. The dwarf males were both attached to the abdomens of the females. They both have the terminal segment of their abdomen like the right hand picture in Figure 10 of the 1932 paper. This species was reported from Dry Tortugas, Florida, and from Bimini from a different species of alpheid shrimp, *Synalpheus brooksi* Coutière.

Diplophryxus synalphei n. sp.

Figs. 3–7

Female.—Deformed (Fig. 7); irregularly asymmetrical; the left side greatly swollen; form globular. No pigmentation. Eyes absent. Length 6.2 mm.

Head deeply sunk in the thorax; longer than wide; on dorsal side; surrounded posteriorly and laterally by first segment of thorax; anterior margin little curved compared to posterior margin. Antennae small, 1-segmented. Mouth parts not visible from dorsal side.

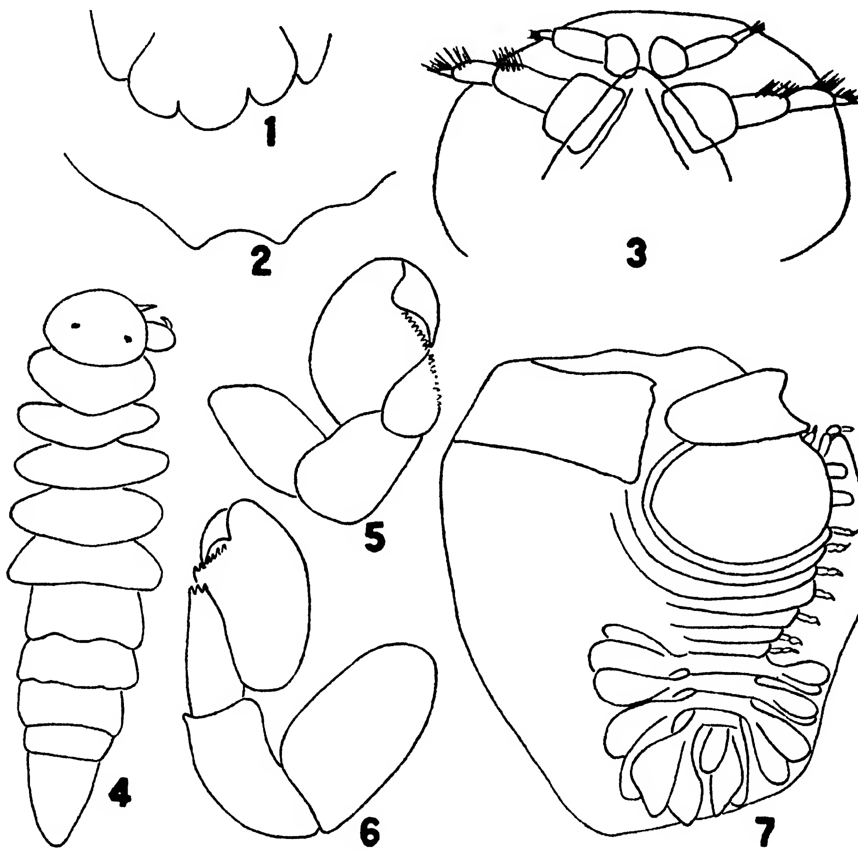
Seven thoracic segments gradually increase in length posteriorly; on the right side they are distinct and each bears a leg; on the left side only the first segment is defined and it only bears a leg. The legs are all small, and end in a small terminal claw.

The abdomen is 5-segmented; the first four segments bear biramous lamellate appendages; the last segment is rounded posteriorly and its lateral margins

are straight and nearly parallel; the appendages on the left side are slightly larger than those on the right.

Both females are ovigerous. Incubatory pouch large; lamellae on the left side are much larger than those on the right.

Male.—Both dwarf males (Fig. 4) were among the eggs in the incubatory pouch of the females. Depressed, slender; length 1.7 mm.



FIGS. 1–7. 1, 2. *Bopyro choprae*, terminal segments of female abdomen. 3–7, *Diplophryxus synalphei*: 3, ventral view of head of male; 4, dorsal view of male; 5, first right leg of male; 6, seventh left leg of male; 7, dorsal view of female.

Head wider than long; first and second antennae 3- and 4-segmented; small eyes present. Legs (Figs. 5, 6) stouter and with the propodus more spinulose on the margin contiguous to the dactyl than in the female.

Abdomen short (0.49 mm.), tapered toward the posterior end, rounded at tip, and rather feebly divided into three segments.

Occurrence.—Pairs were found on the abdomens of ovigerous female snapping shrimps, *Synalpheus fritzmulleri elongatus* Coutière from the Black Rocks off New River at a depth of 15 feet on July 7 and August 10.

Types.—U. S. Nat. Mus. Nos: Female, 90103; male, 90104.

This species differs from others in the genus Diplophryxus (Shino, 1934) in the shape of the last segment and of the head of the female and in the segmented abdomen of the male. Richardson's (1904) *D. jordani* has longer pedicles on the female abdominal appendages. Shino's (1934) *D. alphei* has some tri- and quadiramous pleopods on the female. Chopra's (1930) *D. richardsoni* and *D. kempi* differ in general form and in the shape and structure of the male and female appendages. Hay's (1917) *Phryxus subcaudalis* differs in the number and structure of the thoracic and abdominal appendages and of the last segment of the abdomen of the female; the male abdomen also is rounded distally and 3-segmented.

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CAROLINA BAYS IN RELATION TO THE NORTH CAROLINA COASTAL PLAIN[1]

By David G. Frey

Department of Zoology, University of North Carolina
Chapel Hill, North Carolina

The Atlantic Coastal Plain is a region of many problems and of widely conflicting opinions concerning a number of these. Two of direct importance in the present discussion are the questions of marine overlap onto the Coastal Plain with the possible production of "terraces", and the Carolina bays which occur on these terraces.

COASTAL PLAIN TERRACES

The idea of the Atlantic Coastal Plain being arranged in a series of broad step-like terraces, possibly representing successive sea levels higher than the present, was first conceived in Maryland. In 1907 Johnson described in general terms five of these terraces in North Carolina, and in 1912 Clark *et al.* published a map of the North Carolina Coastal Plain showing six terraces, of which the uppermost one, the Lafayette, was believed to be Pliocene in age and the other five Pleistocene. Fig. 1 shows a somewhat simplified arrangement of these terraces taken from this map; to avoid confusion the many reentrants of lower terraces along the larger streams have been omitted. The five Pleistocene terraces decrease in elevation towards the coast. The limits of these as given by Clark *et al.* are: Coharie 235–160 ft.; Sunderland 150–110 ft.; Wicomico 100–50 ft.; Chowan 50–25 ft.; Pamlico 25–0 ft. Cooke (1935) proposed that the Pamlico terrace was formed during the Peorian interglacial subage, the Talbot (= Chowan) and Wicomico during the Sangamon age, and the Sunderland and Coharie terraces during the Yarmouth interglacial age. No evidence is given for these datings other than the assumptions that the terraces were formed during interglacial ages when the melting of the glaciers made the sea level higher than at present, and that the terraces are arranged in chronological order from the youngest nearest the coast to the oldest at the inner border of the Coastal Plain.

Flint (1940) reviewed critically the evidence for terraces and rejected most of it as inadequate and too conflicting. On the basis of field studies he was able to find and trace only two wave-cut scarps in North Carolina, which probably represent eustatic changes in sea level. The lower one or Suffolk scarp follows approximately the boundary between the Pamlico and Chowan terraces as given by Clark *et al.*; its toe lies at an altitude of 20–30 ft. above sea level. The upper or

[1] This work is being carried out with the aid of a research grant in 1949, Project C-63 from the Carnegie Foundation for the Advancement of Teaching. Previous studies on Singletary Lake by the author referred to a number of times in this paper were assisted by a similar grant in 1948, Project C-50. The author wishes to acknowledge the assistance of Howard T. Odum in 1948 and Richard W. Borden in 1949 in performing the necessary field work and some of the laboratory work.

Surry scarp lies close to the inner boundary of the Wicomico terrace, although in some places it is 15 miles away from the boundary as shown by Clark *et al.* Its toe lies at an elevation of 90–100 ft. Flint states that there is no evidence in the Carolinas for any marine invasions higher than the Surry scarp. This, if generally accepted, would make untenable any theories regarding the Carolina bays as having arisen along the sea coast or in shallow marine locations, unless they are exceedingly old. Flint also states that the general concept of terraces in the sense

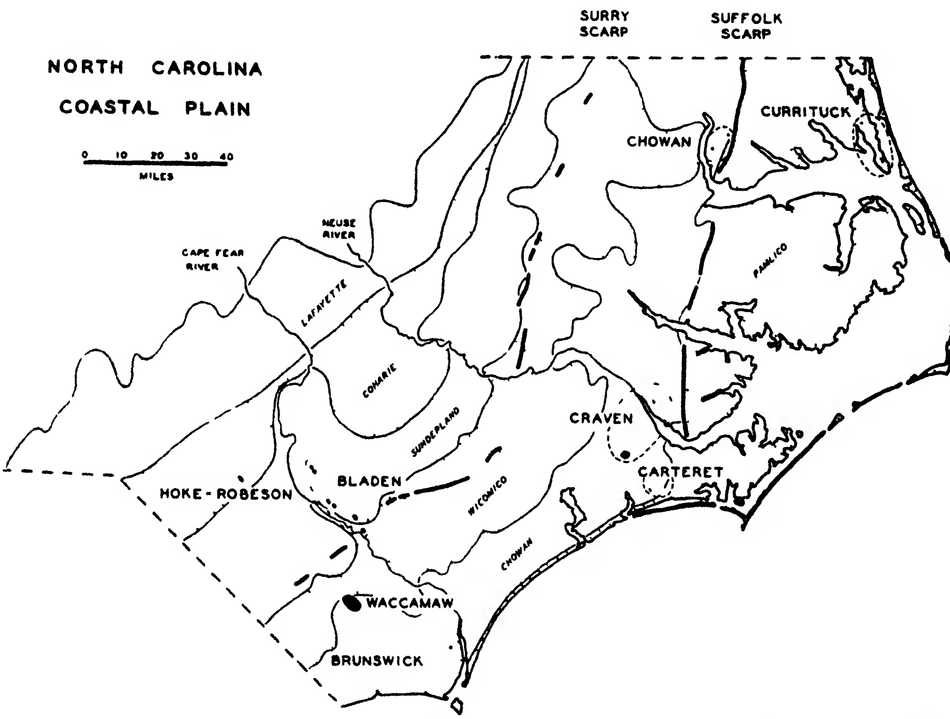

FIG. 1 Location of the Carolina bays sampled in 1949 in relation to Coastal Plain terraces and wave-cut scarps. The terraces are taken roughly from Clark *et al* (1912) and the location of the scarps from Flint (1940)

of equilibrium phenomena resulting from various sea levels should probably be discarded, but in the present paper the original designations will be retained primarily as a convenience for designating general zones of elevation. The two scarps are shown in Fig. 1.

DISTRIBUTION OF CAROLINA BAYS

A second disputed question, which is even less close to being settled than the first, concerns the origin and subsequent history of the very numerous elliptical basins—the Carolina bays—in the Coastal Plain. Theories concerning their origin are quite numerous and have been reviewed by Johnson (1942), but studies concerning the bays themselves have been altogether too few, so that at present

there is no conclusive evidence compelling the acceptance of one or another of these theories.

On the basis of a map showing the distribution of all bays larger than 800 ft. compiled from aerial photographs by the late W. F. Prouty and the terrace map by Clark *et al.*, a count was made for each of the terraces in each of three transverse portions of the Coastal Plain (Table 1).

The bays are not distributed uniformly over the state, as was obvious previously from Fig. 2 of Johnson (1942) or from even a cursory examination of aerial photographs. Of the approximately 2000 large bays in North Carolina, almost 90 per cent occur south of the Neuse River, and more than 50 per cent south of the Cape Fear. Moreover, even in the areas of greatest concentration the bays are not present in equal abundance at all elevations. Omitting the

TABLE 1

Approximate number of Carolina bays greater than 800 ft in diameter in the Coastal Plain of North Carolina, arranged according to the terraces of Clark et al. (1912) and according to three transverse belts

The counts were made in part from an unpublished map by W F Prouty

REGION	TERRACE						TOTALS
	Lafayette	Coharie	Sunderland	Wicomico	Chowan	Pamlico	
Elevation, ft.	>235	235–160	150–110	100–50	50–25	25–0	
Va. line to Neuse River	13	40	45	33	13	30	204
Neuse R. to Cape Fear R	2	188	185	178	74	4	631
Cape Fear R. to S. C. line	10	577	380	22	176	0	1165
Totals	25	805	610	233	293	34	2000

Lafayette terrace which has only a few, some of which are doubtful and most of which are close to the Coharie terrace and may actually be situated on the latter through error in locating the boundary between these two zones, there is roughly a decrease in number of bays with decreasing elevation. Thus the highest terrace, the Coharie, has the greatest number of bays and the Pamlico the least. Assuming that there is a concentric chronological arrangement of surficial Coastal Plain sediments corresponding to the terraces, one is tempted to speculate that the older a formation is the more bays it has. A corollary of this is that the bays are not necessarily all the same age.

PRESENT STUDY: METHODS

In an attempt to gather data concerning the comparative age and ontogeny of basins located at various elevations, a study of the sediments of the Carolina bays which was started on Singletary Lake in 1948 was extended to a number of diverse bays in 1949. Fig. 1 shows the bays and areas sampled in relation to the Coastal Plain terraces and the Surry and Suffolk scarps.

In each area studied several bays were sampled to provide a more nearly repre-

sentative picture than could be obtained from just one bay and to give some idea of possible variation with respect to size. The bays were selected for their regularity of outline so that there would be no question as to their being bays, for the presence of standing water or at least saturated conditions to provide continuous deposition and some protection from burning, for their general accessibility, and for a range of size. With the aid of aerial photographs and a sighting compass (and a machete!) the bay was penetrated to its approximate center. Along the way "soundings" were taken at regular intervals by means of the ⅝-inch steel rods of the Davis peat borer. The total depth to which the rods could be pushed and any pronounced variation in the configuration of the bottom was noted. If the density of vegetation permitted, soundings were taken in various directions from the center to determine if the place selected was in fact the deepest part of the bay that could be conveniently found. When the sampling station was finally decided on, samples of the bay sediments were collected with a Davis peat sampler at 6-inch intervals (or sometimes more frequently as the occasion demanded) from the surface of the bay down as far as the sampler could be pushed and pounded without damaging it unduly. No attempt was made by other means to penetrate the sand or clayey-sand below this level. Sometimes a Hiller-type sampler was used for very soft surface deposits. The samples were preserved in properly labelled plastic screw cap vials for subsequent laboratory analysis.

RESULTS

This report presents just a few of the more general results and a suggestion of what may be expected from a complete analysis of the cores.

Bays are much more uniform when seen from the air than when seen from the ground. From the air they are all ellipses of varying size, oriented roughly parallel to one another in a general northwest-southeast direction. From the ground they are seen to have differing degrees of wetness and different plant communities. The latter are controlled by the prevailing moisture conditions, particularly the length of time each year that the soil is completely saturated with water, by the nature of the soil profile and by the frequency and severity of burning. Wells (1928) has designated the three main types of communities that occur in these wet depressions as swamp-forest, shrub-bog, and savanna-bog. Rockyhock Bay (Ch-3), a good example of a swamp-forest, consisted of a high canopy of large white cedars, sweet bays, and maples, with little shrub understory. More open swamp-forests, such as Cu-1, contained pocosin pines, black gum, maple, sweet gum, and holly, and in addition an understory of cane, ferns, small sweet bay, and abundant sphagnum. Still others had a rather thick shrub understory, with of course a more open canopy. The shrub-bog community, e.g. that of Cr-3 and Br-2, consists primarily of broadleaved evergreens, which in these instances were mainly waist-high to more than headhigh growths of gallberry (*Ilex*), pepperbush (*Clethra*), and titi (*Cyrilla*), frequently held together by bothersome cat briars (*Smilax laurifolia*), with many *Sphagnum*-filled pools below and scattered pocosin pines (*Pinus serotina*) projecting above this mass of vegetation. Other areas, such as extensive parts of Ca-1 and Ro-3, consisted primarily of grass and

TABLE 2

General geographic, morphometric, and edaphic characteristics of the Carolina bays of N. C. investigated in 1949

Lengths were measured without correction from USDA aerial photographs (scale approx. 1 in. = 1667 ft.), and altitudes were interpolated from U. S. Army Corps of Engineers maps, except for Waccamaw and Rennert which were obtained from N. C. Geol. and Econ. Surv. Bull. 27. Elevations of Singletary and Jones were reported previously by Frey (1949a). The elevation of RO-1 was interpolated from a nearby bench mark.

TERRACE	COUNTY	BAY	NAME	APPROX. ELEV.	LENGTH	DEPTH	SEQUENCE OF SEDIMENTS
				ft	*yds.*	*ft.*	
Pamlico	Currituck	Cu-1		10	800	6.0	Thin organic, sandy clay, sand
		Cu-2		10	1060	6.0	Organic, clay, alternating sand and clay
		Cu-3		14	700	4.6	Organic, clay, alternating sand and clay
Chowan	Chowan	Ch-1		41	1030	5.0	Organic, brown sand
		Ch-3	Rockyhock Bay	18	1810	14.3	Organic, clay, organic, sand
	Craven	Cr-1			1150	10.0	Organic, clay, sand
		Cr-2			460	4.4	Organic, sand and clay, sand
		Cr-3			1040	5.8	Organic, sand
		Cr-4	Catfish Lake		3020	6.5	Organic, clay, sand
	Carteret	Ca-1			640	4.5	Organic, sand
		Ca-2			530	8.3	Organic with 2 sand lenses, clay, sand
		Ca-3			950	3.8+	Sandy organic
	Brunswick	Br-1		42	670	4.5	Organic, sand
		Br-2		48	630	4.2	Organic, sand
		Br-3		44	210	2.0	Sandy organic
		Br-4		52	480	4.3	Sandy organic
		Br-5	Funston Bay	45	1960	5.5+	Organic, clay, sand
		Br-6	Pumping Pond		440	16.0	Organic, sand
	Columbus	Wa-1	Lake Waccamaw	41	10820	14 7+	Organic, sandy clay, blue clay
Wicomico	Bladen	Si-25	Singletary Lake	63	3180	21.6	Organic, clay, organic, clay, organic, sand
Sunderland		J-1	Jones Lake	73	2590	17.7	Organic, clay
		Sa-1	Salters Lake		2660	18.4	Organic, clay, organic, sand
		LS-2	Little Singletary		3190	12.3	Organic, clay, organic, silt, sand
		Wh-1	White Lake		3740	12.4+	Organic, blue clay
		Bl-1			930	8.3	Organic, clay, sand
		Bl-2	Jerome Bay		2170	11.0	Organic, clay, sand
Coharie	Hoke	Ho-1			1040	3.5	Thin organic, clay, sandy clay
		Ho-2			740	3.0	Thin organic, clay, sandy clay
		Ho-3			940	5.4	Thin organic, clay
	Robeson	Ro-1		205	580	1.5+	Thin organic, sandy clay
		Ro-2			1020	2.5+	Thin organic, clay
		Ro-3	Rennert Bay	182	4580	7.6+	Organic, clay, sandy clay

ferns. Drier areas of some of the upland bays contained large holly and oaks. Evidence of fires was found in many of the bays.

The sediments occurring within the bays constitute the main material for further work (Table 2). All the bays had a layer of organic matter (ooze, peat, or organic soil) at the surface. This varied in thickness from a few inches in most of the bays examined in the Hoke-Robeson region to a number of feet in most of the other regions. Below this was an inorganic layer consisting of sand in the shallower bays and clay or silt in the deeper bays. The clay (silt) usually rested upon sand except in a number of the Bladen County lakes (Salters, Little Singletary, Singletary) and Rockyhock Bay (Ch-3) where a second organic layer was interposed. In core Si-25 of Singletary Lake two such organic layers were found, making a total of 3 including the now accumulating surface sediment. With the equipment at hand it was not possible to push down into the sand. This is unfortunate, since it has been found in the more extensive studies on Singletary Lake in the summer of 1948 when with the aid of a Wilson sampler samples were obtained well into the sand, that stratified pollen indicating basin deposition occurs in the sand as well.

With the understanding that the depths of sediments here reported constitute only those that could be sampled with the Davis or Hiller devices and do not necessarily represent the total thickness of sediments, it is interesting to examine the relationship between size of bay and depth of sediments. Fig. 2 shows that in general as the size of the bay increases, the depth of the sediments also increases. With the exception of Rockyhock Bay, the seven deepest bays are the ones still containing enough water to be called lakes. Rockyhock Bay is interesting in that it is the only filled-in bay sampled which shows any of the morphometric characteristics of the bay lakes (Frey, 1949a); at the southeast end is a shallow sand terrace extending out from the present shore of the bay for a considerable distance and then dropping off rapidly to the depth sampled. This greater depth of the lake-containing bays suggests that a greater original depth as well as their greater size may help account for open water persisting in these particular localities.

Pumping Pond in Brunswick County does not have the shape of a bay and is probably not a Carolina Bay. It is representative of the numerous small ponds found along much of the immediate coastal region of North Carolina, and is included for comparison with the bays. Likewise Catfish Lake is not a bay. The bottom of Catfish Lake was very irregular, with many "hillocks" of peat projecting above the clay surface of the bottom. In between was a soupy accumulation of flocculent organic matter, and in addition there were many logs on the bottom. There is a strong possibility that Catfish Lake has been reformed relatively recently by the erosion and removal of deposits which obliterated the previously existing water area perhaps during the climatic optimum. Jerome Bay (Buell, 1946) is the only other bay in North Carolina previously reported upon. It is likewise included for comparison.

Scattered references occur in the literature relative to the depth of bays and the nature of the contained sediments. Glenn (1895), to whom credit must be

given for first pointing out the bays and describing accurately some of their characteristics, noted that wells driven into bays showed a "dark fertile, compact clay, impervious to water" extending downward 15 to 25 ft. to the underlying water-containing sand. Johnson (1942) noted that Carolina bays may have a total depth up to 50 ft. below the general plain level. This, however, does not represent 50 ft. of sediments, since the floors of some of these crater-like depressions are themselves as much as 30 to 40 ft. below the surface of the surrounding plain. No such bays have been sampled by the author. On the basis of all existing information it is probably safe to conclude that the Carolina bays are

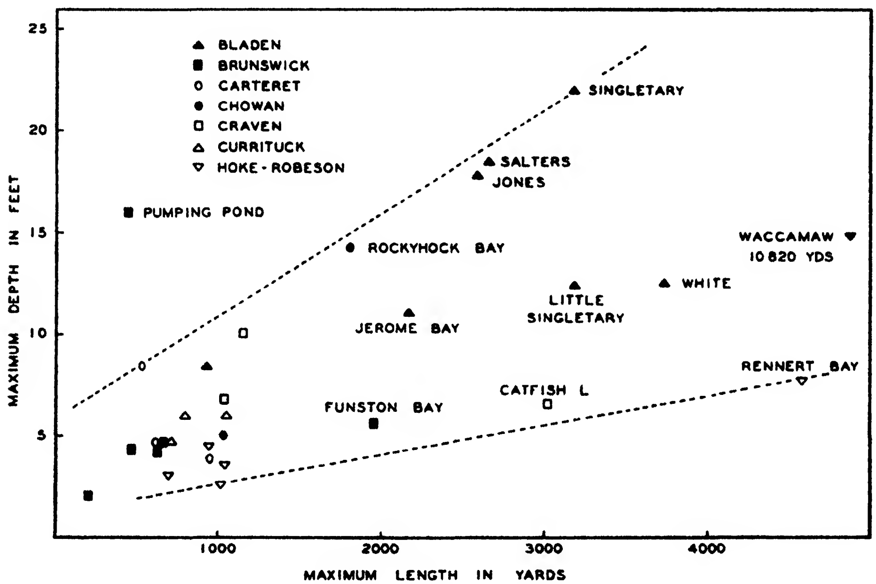

FIG. 2. Relationship between maximum length of the Carolina bays and maximum depth obtained with a ⅜-inch steel rod. Pumping Pond and Catfish Lake are not bays. The data for Jerome Bay are from Buell (1946)

quite shallow, much more so in general than the ice block basins or glacial erosion basins of the northern part of the continent.

ANALYSIS OF SEDIMENTS

The sediments of a marshy or water-filled basin, if not disturbed or severely desiccated and oxidized during their history, preserve a chronological record of plant and animal remains. Long term changes in climate are recorded by changes in the percentage composition of tree pollens in the sediments. Buell (1945) working on Jerome Bay in Bladen County was the first to observe and record spruce pollen from surface sediments of North Carolina. This type of tree, found only in the clay at the bottom of the core, along with a small pine grain identified as *P. banksiana* on the basis of size-frequency distribution, suggests these lowermost sediments were contemporaneous with late Wisconsin time. More recently

the author (Frey, 1949b) has analyzed core Si-25 containing the three organic layers. Although spruce is present in small percentages all the way to the bottom from where it first occurs in the upper part of the silt zone, there are definite ameliorations of climate associated with each of the two lower organic layers, as shown by increased percentages in oak, hickory, and even the occurrence of such pronounced mesophytic species as beech, chestnut, and hemlock. On the basis of these changes it was suggested that the sediments of Singletary Lake

FIG. 3 Aerial photograph of a portion of Robeson County near Red Springs, showing the location of Ro 1 and Ro 2 and their relation to the surrounding surface features. The darker lines are drainage ditches (USDA, Production and Marketing Administration.)

extend back into the Tazewell subage of the Wisconsin glacial age, making this record the longest continuous pollen record known from North America.

Certain regional differences are apparent in the bays which may be a reflection of differences in age. One of the most marked of these is that the bays on the Coharie terrace in particular are filled mainly with dark mineral soils having a relatively thin layer of organic matter on top. When these bays are cleared and drained they can be used quite successfully for agriculture. Fig. 3 is an aerial photograph of a portion of Robeson County near Red Springs taken on Feb. 20, 1938, showing the location of Ro-1 and Ro-2. The bays under cultivation can be readily distinguished by their darker color from the surrounding more sandy country.

Analysis of the cores collected from these and the other bays will enable the

aging of their sediments and the working out of their histories. When means is obtained of sampling the sand deposits—at least the pollen bearing portions—it should then be possible to determine quite readily whether or not all the bays are the same age. In the meantime the more superficial sediments on hand will be valuable in helping determine the influence of glaciation on the southern United States and possibly of following the retreat and advance of vegetations with changing climatic conditions.

SUMMARY

Although Pleistocene marine influence has not been demonstrated in the Carolinas at elevations greater than 100 ft., the peat-filled Carolina bays are more numerous above this level than below. There is a general decrease in number of Carolina bays with decreasing elevation on the several Coastal Plain terraces. The depth of sediments down to impenetrable sand or sandy clay roughly increases with increasing size of the bay. Those bays still containing lakes are in general the deepest, suggesting that an original greater depth of the basins may have helped in the preservation of the water areas. In the two studies thus far on the pollen of bay sediments, spruce has been found in the inorganic layers below the superficial organic layer. In Singletary Lake two lower organic layers were associated with ameliorations in climate, although these were not intense enough nor of long enough duration to cause a disappearance of the spruce. The usefulness of pollen analysis in working out the age and ontogeny of these basins and of studying changes in vegetation during Wisconsin time is indicated.

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THE HISTORY OF THE DISCOVERY (1600–1680) OF THE SPIRAL VALVE IN THE LARGE INTESTINE OF ELASMOBRANCHS AND A GANOID

By E. W. Gudger

American Museum of Natural History
New York City

INTRODUCTION

In the lower vertebrates, but especially in the Elasmobranchs, Ganoids, and Dipnoans, there is found that curious twisted outgrowth beginning anteriorly on the interior dorsal wall of the intestine and extending to the caecum, the spiral valve, similar perhaps to the typhlosole of the invertebrates (*e.g.*—the earthworm). In the fishes under study, it is an organ of many varying forms, but always fundamentally a spiral. Its function is to slow up the passage of food materials through the short intestine and by its greatly increased and highly vascularized surface, to promote absorption of the digested food. This is necessary because these fishes lack the long convoluted intestine of the higher animals in which absorption is facilitated.

I have long had it in mind to trace the history of the discovery of this very interesting structure. Knowledge of the relatively early investigation of the spiral valve in Elasmobranchs first came to me while serving as editor of Vol. III of the Dean Bibliography of Fishes. In 1921–22, while working on the Pre-Linnaean Section therein, references to Steno and Perrault were found and listed. Later the Museum Library procured copies of Adelmann's Fabricius and of Maar's Steno. Then I found Severinus in the Surgeon General's Library in Washington, D. C., and had a photostat copy made for our Library. But study of all these led to the belief that there must be other old anatomical works having descriptions of spiral valves embedded therein. Thus matters stood until knowledge of the subject was much advanced by the publication in 1944 of Dr. F. J. Cole's outstanding "History of Comparative Anatomy." In this he reproduces a number of the old figures of the spiral valve and gives brief citations in his text, but, in his invaluable bibliography, he cites authors, titles, years, and editions. In addition to the data in his book, Dr. Cole has by letters and photographs of texts and figures greatly helped my work along.

But for this article I must have full citations and not all the works needed are available in our library. Furthermore, these descriptions, in these old books in which they are found, are "embalmed in that most excellent preservative—the Latin language." But alas my Latin is far in the past. However, help in this matter has come from Prof. Henry T. Rowell, head of the department of Latin in the Johns Hopkins University (my alma mater), who, with equal accuracy and kindness, has translated these excerpts for me. The help of both Prof. Rowell and of Dr. Cole is gratefully acknowledged.

With the kind aid thus given, I have endeavored to work the data on the history of the discovery of the spiral valve into a chronological narrative. But even with all this assistance the task has not been an easy one.

THE DISCOVERY OF THE SPIRAL VALVE IN ELASMOBRANCHS

As will be seen herein, the narrative of the discovery of this curious structure in various Elasmobranchs is a tortuous one. Great difficulty has been had in tracing the steps whereby each discovery was made and made known. These early anatomists did not always make full dissections of their sharks and rays and write clear descriptions of what they found, publication was difficult, and they did not always illustrate their books by drawings. Thus at least one early writer barely missed the discovery of the winding valve.

A "Near Miss", 1600

0.—Hieronymus Fabricius ab Aquapendente (1537–1619), an Italian who lived at a waterfall (as his cognomen indicates), published at Venice in 1600 a general study entitled "De Formato Foetu." Prof. H. B. Adelmann of Cornell University has published a facsimile edition (1942) of this work with a translation and with photographic copies of the original figures and copious critical notes. The "De Formato Foetu" has seemingly been published under various dates at various places. Adelmann used the fine copy in the College of Physicians of Philadelphia in which "the date, 1600, on the engraved title page has been altered by hand to 1606" (Adelmann, pp. 129–130). This copy was accompanied by thirty colored plates and ten leaves of printed explanatory matter. A short section of this book is "A Dissection or Description of a Pregnant Shark" (*Piscis galeus—Mustelus vulgaris* of the present day). This is found on pp. 373–375 of Adelmann.

The figure of the shark with the abdominal wall split and spread apart to show the viscera, is portrayed in the author's Tab. XXXI, Fig. LXIX (Adelmann, p. 571). It is reproduced herein as Fig. 1. Here we see, in the lower right side of the abdomen, the hinder intestine (his "F. intestinum colon"). On the exterior are plainly shown in the intestinal wall the bases of the turns of the spiral valve. Had Fabricius split open the intestine, he would have seen and surely have figured the winding valve. This failure is explicable only by reason of the fact that he was preoccupied with the matter of viviparity in his shark. His next figure (Tab. XXXII, Fig. LXXI) portrays the opened abdomen of the shark with the split-open uteri in situ showing the foetuses within. He also figures an excised and opened uterus with the young.

So far as this search reveals, Fabricius is the first to attest by drawings (non-placental) viviparity in a shark. But he never knew how narrowly, by failure to dissect the intestine of his shark, he missed making the initial discovery of the spiral valve. The best that can here be said for him is, in the phraseology of the airplane bombers of World War II, that he made a "near miss."

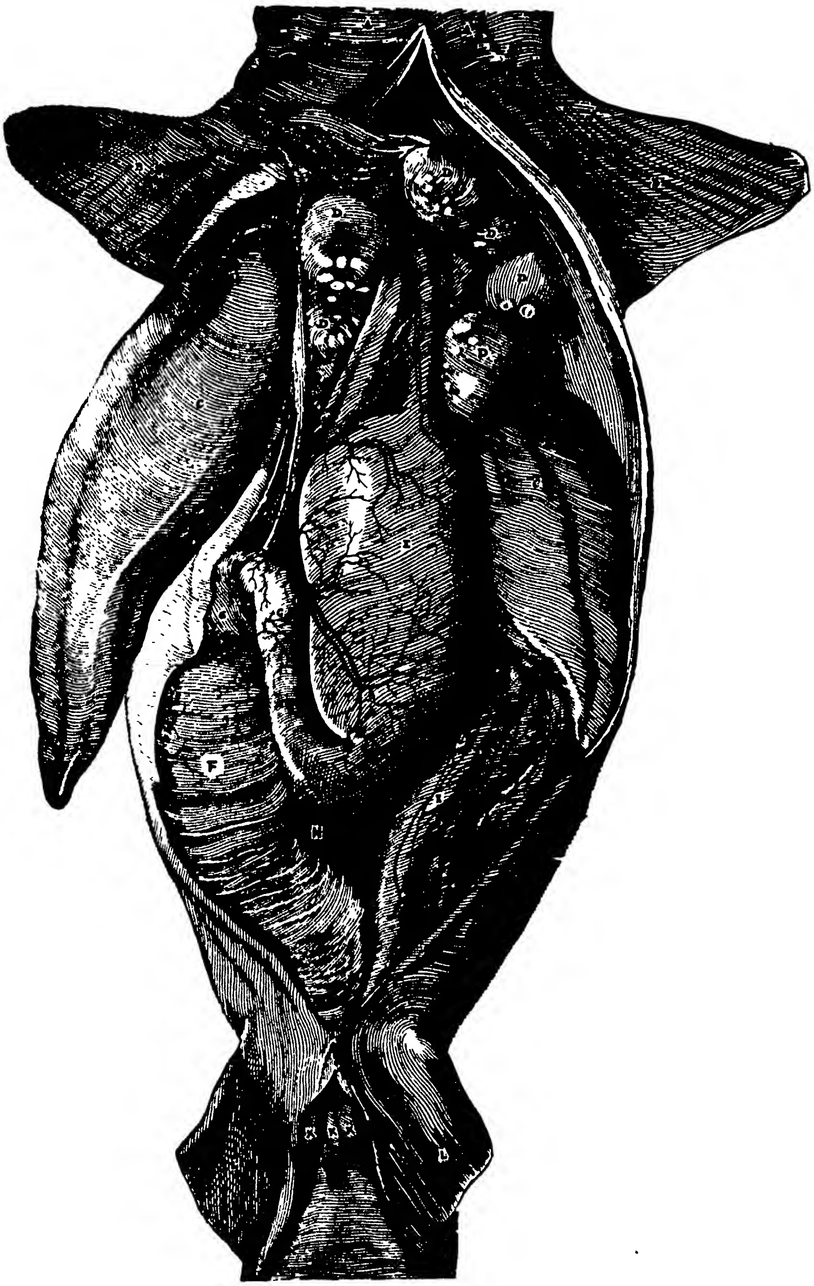

FIG. 1. An excellent drawing of the split-open abdomen of *Galeus laevis*, showing the viscera. Note on the lower right the undissected "intestinum colon" (F) showing the bases of attachment of about 12 turns of the spiral valve. The hinder turns are not clearly shown. After Fabricius, 1600.

The Discoverers, 1645–1680

The findings of these men will be presented in chronological order even though the author's name and second discovery must in some cases follow that of another anatomist.

I. (1, 2)—Marcus Aurelius Severinus[1] (1580–1656), also an Italian, published his "Zootomia Democritea," Noribergae (Nuremberg) in 1645. On p. 127, he presents a drawing (Fig. 2 herein) showing the excised hinder intestines of two Elasmobranchs. These are labelled "Canicula Aristotelis" and "Torpedinis."

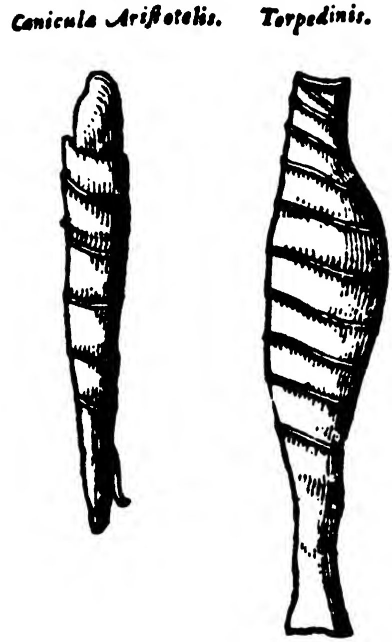

FIG. 2. A diagrammatic drawing of the excised but undissected hinder intestines of Canicula Aristotelis and Torpedo showing the bases of the spiral valve in each.
After Severinus, 1645.

The spiral lines on the exterior of each intestine plainly show the basal outgrowths of the winding valves from the interior of the intestinal wall, but nowhere does Severinus refer to these. However, three lines above the figure, he says that—"In the intestine of both Raja & Galeus is found an admirable structure noticed by neither Rondelet nor Aquapendente." This presumably refers to the spiral valve, but Severinus neither figures nor describes at this point this "admirable structure."

On page 357, Severinus portrays in external aspect the entire digestive tract of

[1] The Roman numerals indicate epochs of discoveries of spiral valves and the men who made them. The Arabic numerals indicate the number of discoveries reported by the investigator at this point. They are cumulative—thus Steno II (3, 4). Swammerdam's ganoid discovery is set apart from his and other elasmobranch discoveries.

a Galeus excised and drawn in its entirety. This is reproduced as Fig. 3 herein. On p. 358 he says (translation by Prof. Rowell)—"The intestine of a Galeus of the first species is short and large. Its exterior is the color of blood. A double vein enters it from above, and above and below are three oblique twigs or sprouts [surculis] corresponding to each other, under which in the interior there are rather wide little membranes twisted into spirals to delay the feces." Now if for "obliquis surculis" we could read obliquis circulis—"oblique circles . . . under which in the interior there are rather wide little membranes twisted into spirals," the description would exactly fit the drawing (Fig. 3). It seems that here there is an undoubted typographical error.

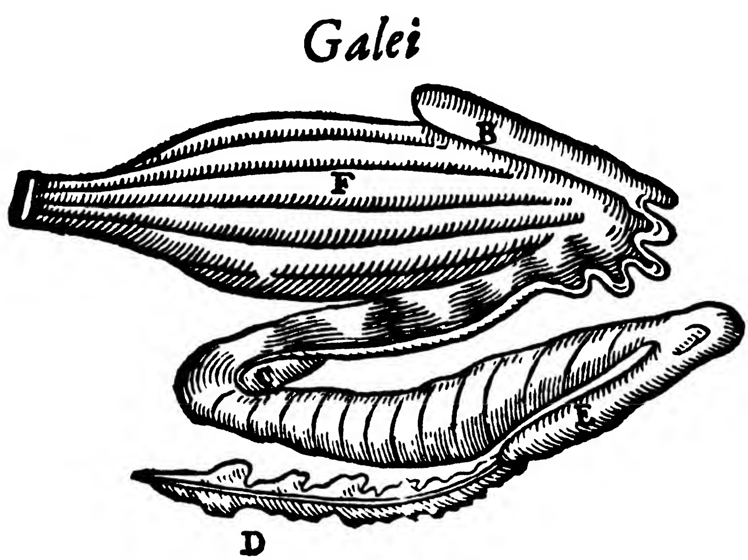

FIG. 3. The digestive tract of a Galeus removed and drawn. Note the 12 oblique turns of the bases of the undissected spiral valve in the hinder intestine.
After Severinus, 1645.

In Severinus' next paragraph, we read—"In the middle of the straight intestine a circle ["circulus"] of membrane is fixed, turning towards the rear. Its purpose, obviously, is to prevent [slow down] the escape of the juice [digested material]." It is significant that here circulus is used and not surculus. Surely surculus in the paragraph above is a typographical error for circulus.

On p. 371, Severinus begins a section headed "In Torpedine." At the end of this (p. 372) is found this statement—"The colon is large, but a little smaller than the ventriculus [little stomach]. The lower intestine is ingeniously equipped with coracoid [?] coils ['spiris coracoidis'] on its inner surface such as I have elsewhere mentioned for Raja, Caniculi [dogfishes], and Lupus [?]."

Even though Severinus did not figure a split-open elasmobranch intestine to show the winding valve, he portrays three intestines in external view showing the bases of the valves. These figures and his description of two valves (especially

when the presumed typographical error is corrected) do make it clear that Severinus saw this structure and recognized its function. Hence Severinus must be declared the Discoverer of the Spiral Valve in Elasmobranchs.—But, as will be seen, the next old anatomist to be quoted did a progressively better job.

Nicolaus Steno (1638–1686), or Niels Steensen in his native Danish, is the early anatomist whose successive descriptions and figures leave no possible doubt that he dissected, saw and understood the function of the winding valve in the intestine of several elasmobranchs.

Steno's collected works were published in two volumes (in one) at Copenhagen in 1910. His books and articles were edited with copious valuable notes by Vilhelm Maar. The printing is in good clear type and the figures are admirably reproduced. But unfortunately the editor did not put at the foot of the photographic reproduction of the original title page of each article the place and date of its original publication. These omissions surely impair the value of this fine piece of work. But I have, so far as possible, supplied them with a pen in our copy. What follows is from Maar's edition.

II. (1)—Steno in 1664 finished his "De Anatome Rajae Epistola" and dedicated it to Willem Piso (of Brasilian natural history fame). It seems to have been first published separately in 1664, and then republished in his "De Musculis & Glandulis Observationum Specimen" at Hafnia (Copenhagen) in 1664. Our interest is in the intestine and its valve. Here follows Prof. Rowell's translation.

Steno says [Maar, I, p. 199] that:

The inner surface of the intestine of the ray is covered by its own [mucous] coat, which, however, was not as thick as that of the small stomach (ventriculus). If you turn it over undissected, you will see standing out from the coat directly behind the pylorus a sort of fibrous material which has the exact form of a spiral and descends to the region of the caecum. . . . There are three series of fibers in this snail [valve]. Two on the outside ascend at a slant from the covering of the intestine to the edge [of the valve?]; the one in the middle runs lengthwise but not in a straight line. Not far from the end of this snail-like layer is seen the exterior of a sort of sinewy base. It is white and ends in threads. I think that these threads are nothing but its fibers gathered together there and twisted toward what is below. This body or region [the space between the spiral markings?] is not small. It is two or more fingers wide and wraps itself eight times around the intestine. . . . Thus in a very short intestine, the coils have the appearance of a snail's [shell] coils, which [coils] very long intestines make in other animals.

Here then is the evidence that Steno dissected the intestine of a ray and saw and described the spiral valve therein and understood its workings (ante 1664 —the date of publication). It is very unfortunate that he did not have a drawing made.

II. (2)—Steno in 1667 published in Florence his "Elementorum Myologiae Specimen," etc. One of the component parts of this was the "Historia Dissecti Piscis ex Canum Genere "(*Scymnus lichia*). Of interest to us just here is what he

writes about the intestine (Maar, II, p. 152). "There were two notable things about this intestine. 1.—A muscular coat as thick [wide?] as a middle finger was composed of fleshy spiral fibers. 2.—It has a membranous snail [valve] which fills the entire cavity. The intestine itself was a span in length. The edge of the snail [valve] towards its axis was five spans long. The excrement in this snail [valve] had taken on a yellow color." Here again Steno unfortunately has no figure.

Later Steno dissected the embryos of two other sharks and figured their spiral valves. But chronologically he must be set aside for a few years to bring in another man who also in 1667 discovered a spiral valve in another shark and gave the best figure (1671) of any of the early anatomists.

In 1666 the Academie Royale des Sciences was constituted in Paris. It was shortly divided into sections according to the interests of its members. These met not for the reading of papers like our present day scientific societies but they were working groups (like our laboratory students) for the examination and study of specimens. The group of physicists, as the biologists were then called, was particularly interested in animal life. These men (presently to become known as the "Parisians"[2]) met for the dissection mainly of foreign animals that had died of disease in the Royal Zoological Park.

There is every reason to believe that Claude Perrault was the leader of the anatomists. He was a distinguished architect and physician—a man skilled in the handling of fine tools and in a knowledge of anatomy, who could (and presumably did) take the lead in the dissections and in the descriptions of the organs found—these being matters particularly in his field. There is every reason to believe that Perrault's text was read to and discussed and possibly amended by the company, but we must believe that the final text was mainly his work.

III. (1)—Claude Perrault (1613–1688) is by all hands pronounced the dissector and writer of "Observations qui ont este faites sur un grand Poisson dissequé dans la Bibliotheque du Roy, le vingt-quatriéme Juin, 1667." Herein first appeared the description of the spiral valve of the "grand Poisson" (*Alopias vulpes*), a thresher shark or "marin renard," but without a figure. This article on Alopias and the description with figures of the dissection of a lion, were published in quarto in 1667 as a brochure of 27 pages without title page. But with

[2] The Parisians, like many other students, started with small beginnings. Their first brochure of two articles was published without title page and in quarto size at Paris in 1667. By 1669, five more dissected animals had been added to the list. And in 1671, a volume in folio appeared under the title "Mémoires pour Servir à l'Histoire Naturelle des Animaux, Dressés par M. Perrault, etc" These Memoirs were illustrated with copper plate engravings. As Cole's bibliography (1944, p. 501) shows, the memoirs appeared with additions in many editions over many years, and formed a sure foundation for the study of comparative anatomy.

For an extensive and illuminating discussion of the "Parisians" and of their work and publications—and especially of Perrault's outstanding part therein—see Cole (1944, pp. 393–442). Cole has gone into bibliographic refinements, and has made bibliographers and librarians his debtor (1944, p. 501).

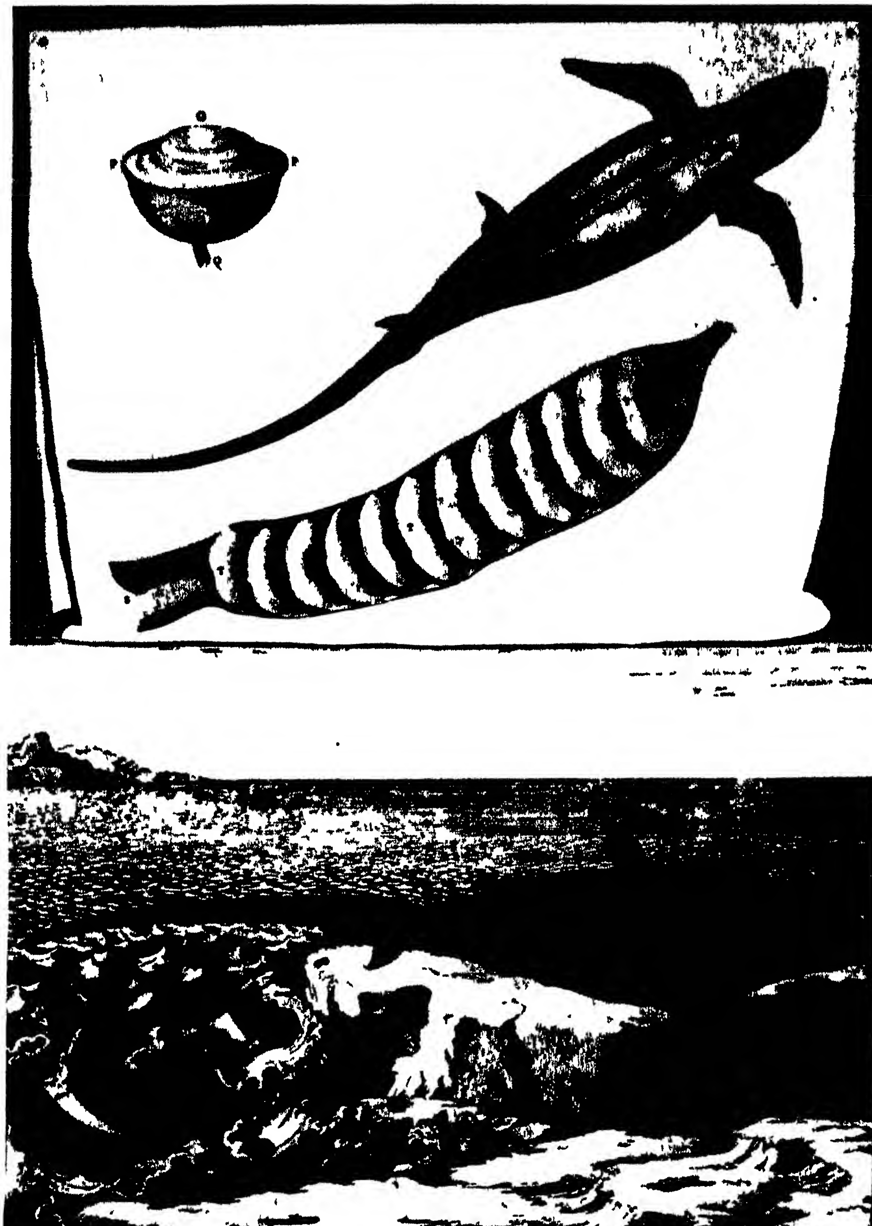

FIG. 4. Below is shown lying on a ledge of stone a "renard marin," a fox or thresher shark. At the top is seen the shark with abdomen slit open to show the viscera Below it is the spiral valve of 12 coils with half the intestinal wall removed. Note the opening in the center of each coil. This is the first and best of the early published figures of the spiral valve of a shark.

After Claude Perrault, 1671.

the like work on other animals, the two articles above appeared in folio at Paris in 1671, bearing the title "Memoires pour servir à l'histoire naturelle des animaux." In this the figures for the "grand Poisson" were first published and 1671 is their date. Fig. 4 herein is copied from the 11 x 15½-inch original. It is the first figure of a spiral valve ever published. In later editions from 1676 on, other dissections and figures appeared in the growing "Memoires."

According to the description (1667), the "grand Poisson" was 8½ feet long. The large intestine was about 18 inches long and 3 broad. For 13 inches of its length (to the caecum), it had a peculiar structure. Instead of an intestine with the ordinary convolutions found in other animals, this was a straight tube whose cavity was interrupted by several separations composed of the lining membrane of the gut folded inward. These separations were about half an inch distant from each other and turned round like the shell of a snail or a staircase with an open center (one lacking a central supporting post). This valve, the description goes on to say, is the means by which food material is held back and is a great while in passing, although the way is very short.[3]

The drawing from the 1671 folio is reproduced herein as Fig. 4. Disregarding the eye in the upper left area, note that at the bottom the long-tailed shark is portrayed lying on a ledge of stone. Above is shown the shark with the abdomen slit open to show the viscera. Our attention, however, is centered on the figure of the large intestine which has been cut out and has had half of its intestinal wall removed to show the spiral valve in situ. Note the hollow center of the valve extending from anterior to posterior through the 12 coils of the valve. This finely portrayed valve is far beyond the crude figures of the other valves presently reproduced.

Now in turn we must leave Perrault behind (to be returned to in 1680) to bring forward two anatomists who published notes and figures of spiral valves in the early 1670's. The first of these is a newcomer, the Dutchman, Swammerdam, who produced a notable drawing with a very brief and inadequate description.

IV. (1)—Jan Swammerdam (1637–1680) in 1673 published in the fourth revised edition of Thomas Bartholin's "Anatome", issued at Lugduni Batavorum, two splendid figures of the spiral valve of a Raja (Fig. 5 herein). No. I in the figure is of the "Dissectum intestinum inversum" [turned inside out] and partially split. No. II is of the intestine with one-half of the wall removed to show the valve in situ. No. III is of the valve removed and drawn as a separate object. Note the slight perforation in the center of each of the turns.

[3] It should be said that no definite statement has been found in this study that Perrault dissected the shark and wrote the description of what was found. If all the editions and republications of this article (some 15 or 20 in number) could be examined, some light might be found to clear up the matter. But by common consent of bibliographers, librarians, and anatomists, the article is attributed to Perrault. At least one edition of the "Mémoires pour Servir" reads on the title page—"Dressez [arranged] par M. Perrault," and another "Redigez [edited] par M. Perrault."

In the first account of the spiral valve of a ray (1664), Steno gives a full description but no figure. In the ray under study, Swammerdam (1673) gives two good figures of the valve and almost no description. After noting that the intestine is turned inside out and partly dissected (I in the figure), he gives 2½ lines to the valve as follows: "A valve like a snail [shell] in the intestine of the Raya is seen in figure II, as by one looking at it from the outside. It is seen in figure III with all its coverings (literally: tunics) removed."

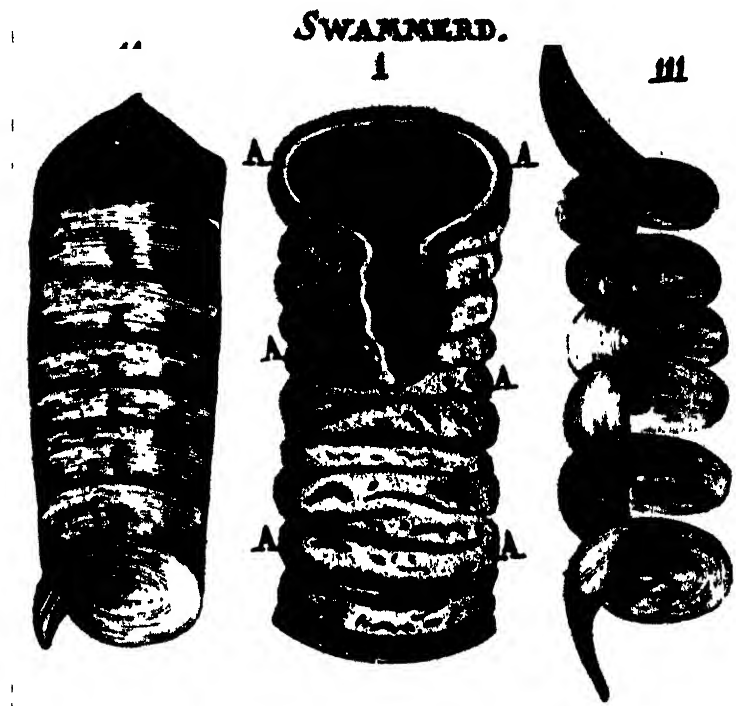

FIG. 5. Excellent figures of the spiral valve of a ray—the first ever published. I. shows a section of the everted and partly split intestine; II. is of the valve with half the intestine removed; III. portrays the valve removed from the gut.

After Swammerdam, 1673A.

Of the history of these drawings, it is simply noted [by Bartholin?] that Swammerdam had communicated them through "our common friend, G. Blasius." Bartholin's "Anatome" (1673) is a very rare book, and none of the early anatomists who worked on the spiral valve nor Dr. Cole at the time of the publication of his book (1944) knew of these figures by Swammerdam. Dr. Cole found them later, and to him I am indebted for photographs of the valve and of the text quoted herein.

Having considered Swammerdam's unique figure, we now return to our grand old Dane, Nicolaus Steno, who, in addition to his previous discoveries of the

spiral valve in 1664 and 1667, now adds two more Elasmobranchs to his list with figures of their valves.

II. (3, 4)—Steno in 1675 published in Copenhagen in Acta Medica & Philosophica Hafniensia his "Ova viviparorum spectantes observationes," in which he figured but did not describe the spiral valve in two shark embryos obtained by dissecting the oviducts of two pregnant viviparous mothers.

In *Galeus laevis* (the "hound"), he found three foetuses in each oviduct. One of these he dissected and on his p. 220 (Maar, II, p. 170), he portrayed the alimentary tract as removed from the body of the foetus. This is shown herein as Fig. 6. Steno speaks of the "cochleatum intestinum" but does not describe it. *Galeus laevis* is a placental viviparous shark (as Fig. 6 shows) and Steno was particularly interested in the manner of nourishing the embryo by this placental apparatus.

Steno was the first to figure in a shark the yolk-sac placenta and its yolk-stalk connection with the intestine of the foetus, but he was not the first to see it. Aristotle (384–322 B.C.), the great Father of Natural History, wrote of this apparatus as follows: "The young in the womb develop with the navel-string attached by a sucker to the womb, so that as the egg-substance gets used up, the embryo is sustained to all appearance just as in the case of quadrupeds." (Historia Animalium, VI, 10, D'Arcy W. Thompson trans., Oxford, 1910).

In Steno's day there was, of course, no knowledge of the osmosis of digested food materials from the blood-vessels of the uterine wall of the mother into the like vessels of the placenta of the foetus. However, he was the first to figure the placental yolk-stalk connecting the wall of the maternal uterus with the beginning of the spiral intestine in the foetus of a shark (Fig. 6 herein).

In the same article, Steno (1675) describes the dissection of another pregnant viviparous shark—his "Spina piscis" (*Acanthias vulgaris*) with young free in the oviducts (uteri). On one side he found one foetus, and on the other "gemini" (twins). He opened the abdomen of one of the "pisciculorum" and figured the digestive tract on his p. 203 (also in Maar, II, p. 172) (Fig. 7 herein), for comparison with that of his young *Galeus laevis*. The little dogfish drew its sustenance only from the yolk-sac (D). In some non-placental Elasmobranchs, after the yolk-sac is exhausted, the young are fed on a milk-like fluid secreted by the villous outgrowths from the uterine mucosa. Steno several times refers to the "cochleatum intestinum" of the two foetuses but nowhere describes it as shown in Figs. 6 and 7. Evidently the presence and function of the spiral intestine had been so established by him in a ray and in another shark that he concluded that it needed no further discussion here.

From Steno, with his high record of two descriptions without figures and two figures without descriptions, we now return to Perrault, who in 1680 figured and described an entirely new type of elasmobranch spiral valve—the "scroll" or cornucopia valve.

III. (2)—Perrault in 1680–88 published his "Essais de Physique, ou Recueil de plusiers traités touchant les choses naturelles" in 4 vols., 12 mo. Paris. This

work is so rare that the only copy in England is in the library of Trinity College, Cambridge, but Dr. Cole has an edition published in 1721. From vol. III of this, which is identical with the original edition, except in size, he has sent me a photograph of Perrault's figure XV (1680). This is reproduced as Fig. 8 herein.

In this figure, Perrault's No. I does not concern us. No. II is the spiral valve in the dissected intestine of the thresher shark, *Alopias vulpes*, which has been already reproduced herein as Fig. 4 (1671). For his No. III the description reads as follows: "Fig. III represents the intestine of another fish called Morgast,

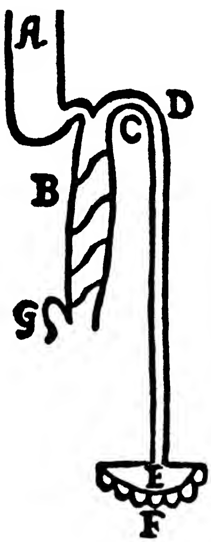

FIG. 6.

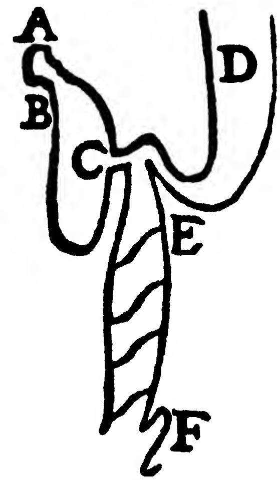

FIG. 7.

FIG. 6. A diagrammatic figure showing the ventriculus (A), the placenta (E & F), the yolk-stalk canal (D) emptying through the insertion (C) into the spiral intestine (B). G is the caecum. This is the earliest known figure of this placental apparatus in a shark.

After Steno, 1675.

FIG. 7. A diagrammatic drawing of the nutritive apparatus of a viviparous non-placental or yolk-sac-nourished shark embryo—*Acanthias vulgaris*. D is the yolk-sac and its tube—this opening into the spiral intestine (E). F is the caecum.

After Steno, 1675.

which is the *Galeus glaucus* of the ancients [the *Carcharias glaucus* of today]. It [Galeus] has also a single sheet of tissue very large and rolled as a horn [cornucopia] of small size. It is represented as being cut open obliquely to enable one better to understand its structure." This is the first published figure, so far as this search reveals, of a spiral valve in an elasmobranch other than a winding or screw valve without a central rod of support. And with this discovery of the scroll valve and the publication of its figure, the history of the discovery of the winding valve in sharks and rays may be considered ended.[4]

[4] The reader seeking to learn about the structure and development of the spiral valve in Selachians should consult R. Kantorowicz, Zeitschrift Naturwissenschaften, 1897, vol.

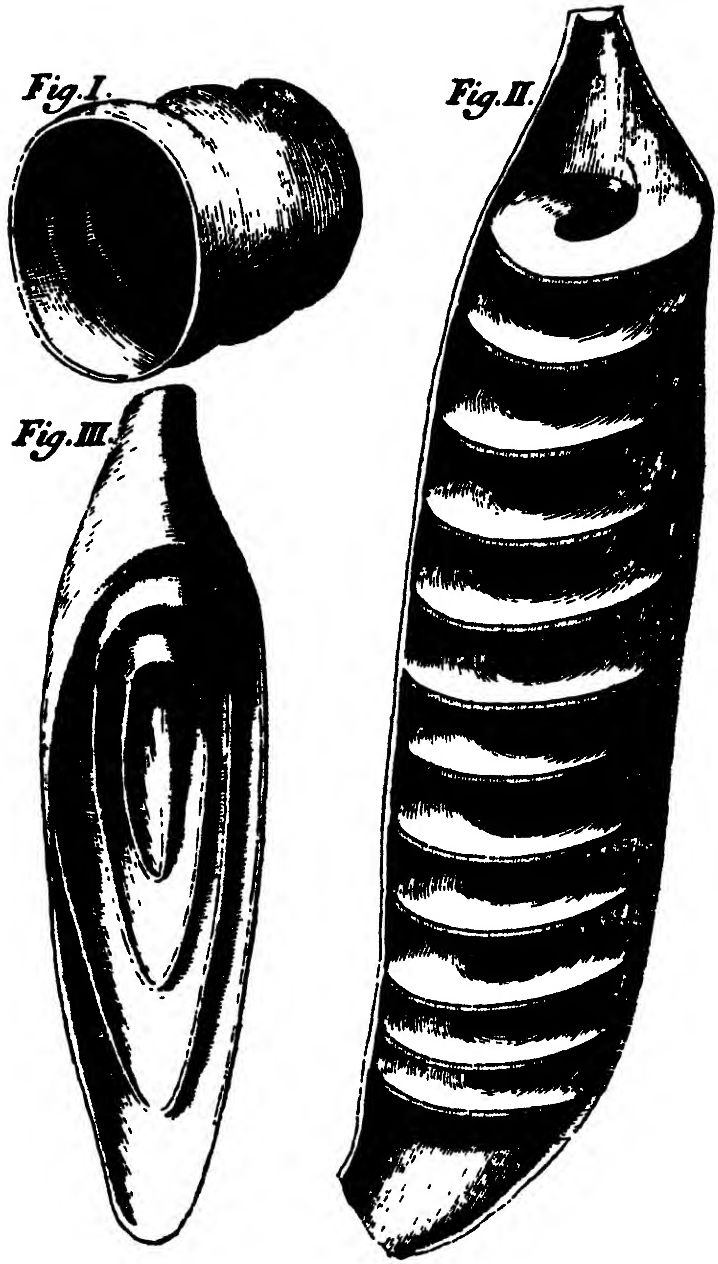

FIG. 8. Excellent drawings of the spiral valves of two sharks. Fig. I is of no concern to us. II is the spiral valve of the "marin renard" (*Alopias vulpes*). III is the scroll valve of the Morgast or *Galeus glaucus* (the *Carcharias glaucus* of the present day). This has been cut obliquely to show the winding structure

After Claude Perrault, 1680.

About 1664, there was established in Amsterdam a fore-runner of the Paris anatomists and their "Academie" (1666). This was the "Collegium Privatum Amstelodamensis", which had a name but not a home. In 1667, the College published a little brochure, about 3¾ x 6½ inches in size and with a total of 45 pages and 2 plates, under the title "Observationes Anatomicae Selectiores Collegii privati Amstelodamensis." In 1673, it completed the volume with 53 pages of text and 10 plates with the title "Observationum Anatomicarum Collegii privati Amstelodamensis, Pars Altera." This little book is so exceedingly rare that Reading University has reprinted a facsimile edition under the editorship of Dr. Cole. He has presented a copy of this to the Library of the American Museum of Natural History.

THE SPIRAL VALVE IN THE INTESTINE OF A GANOID

In 1673 there was published, in Pars Altera of the little book above noted, an unsigned article simply entitled "Acipenser." It and its two plates covered 5 pages of this diminutive booklet. Cole, who has gone into the matter more deeply than anyone else, attributes it to Swammerdam—who was the leader of the "Amsterdammers."[5]

IV. (2)—Swammerdam (1637–1680) gives a drawing (Fig. 9 herein) which is of particular interest because it shows the intestinal tract of the sturgeon with one wall removed (1673B). Here we see the "elegans Cochlea (H) in intestino tenui," or rather the remnants of the spiral valve left after dissection of the ventral surface of its coils. Note the "Scopus cochleae" (K), or central post of the valve —the first and only such "newel" post in any winding valve studied herein. The text (Prof. Rowell's translation) says that Acipenser has—

> a rather thick intestine which is smooth on the outer surface. On the inside it is rough and uneven and covered with a granular layer (or crust). As the intestine comes to its hinder part, it has small valves or certain sinewy bodies at a distance of three fingers from each other. These cut across the intestine obliquely and thus give the appearance of some sort of a snail [shell].

So far as this research has found, this is the earliest figure (1673) of the spiral valve of a ganoid. The publication of it and its brief description establish the fact that this Ganoid—the only one found in Europe—has a spiral valve.

With the publication in 1673 of Swammerdam's figure and description of the spiral valve in a sturgeon, its presence in all ganoids is a strong presumption.

70, 337–364, pl & 4 text-figs There is no general work known to the present writer in which the various kinds of spiral valves in elasmobranchs are brought together and studied The paper most nearly approaching such treatment is by T. J. Parker in Transactions Zoological Society of London, 1880, vol. 11, 49–61, 2 pls. (23 figs.).

[5] For the men who made these "Observationes," and published this little book, Cole suggests this group name—correlative with that of the "Parisians."

Furthermore, the presence of the valve found in various sharks and rays from 1600 (and particularly in 1645) to 1680, definitely established its presence in all

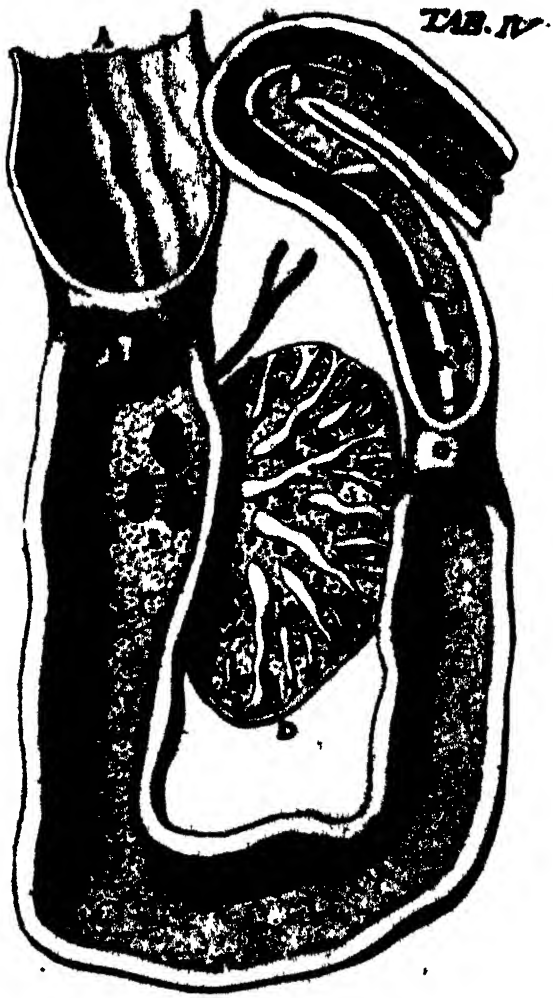

FIG 9 The first published figure of the spiral valve of a ganoid—the dissected intestinal tract of a Sturgeon Note particularly in the upper right the "elegans cochlea in intestino tenui" (H) The valve is largely dissected out but is represented diagrammatically by a winding dotted line Also note the "Scopus cochlea" (K) or central post around which the valve winds This is the first-known figure of a "newel post" spiral valve

After Swammerdam, 1673B.

Elasmobranchs. The discoveries are put succinctly in the following Recapitulation, in which it will be seen that Severinus is the discoverer and that Steno and Perrault have done most to establish the presence in sharks and rays.

RECAPITULATION

There are recorded herein the discoveries of

NINE SPIRAL VALVES IN ELASMOBRANCHS

A "Near Miss"

0.—Fabricius (1600). Fig. 1.—Abdomen of *Galeus laevis* slit open to show the viscera. Intestine unopened but showing on the exterior the internal bases of the spiral valve. No dissection of the gut—a "near miss."

The Discoverers

I. (1, 2)—Severinus (1645). Fig. 2.—External view of hinder intestines of Canicula and Torpedo, each showing external markings of the internal valve. Fig. 3.—The whole intestinal tract of Galeus shown in ventral view. Markings on undissected hind gut are very clear. Valves not figured but described for Galeus and Torpedo (from other specimens?).

Severinus—the Discoverer.

II. (1).—Steno (1664). Spiral valve of Raja not figured but well described and action explained.

II. (2).—Steno (1667) did not figure but clearly described the spiral valve in a shark—"ex Canum genere" (*Scymnus lichia*).

III. (1).—Perrault (1667) described the winding valve in the hind intestine of a thresher shark (*Alopias vulpes*) and in 1671 illustrated his description by an admirable drawing (Fig. 4 herein). This is the first published drawing of a spiral valve of a shark.

IV. (1).—Swammerdam (1673A) published a plate of three figures (No. 5 herein) showing the intestine of a Raya: (I) turned inside out and partially split, (II) a spiral valve with half the intestine removed, and (III) the valve drawn separately. His description is very brief. These are the first published figures of the winding valve in a ray.

II. (3 and 4).—Steno (1675) portrays (the earliest figure) the placenta-yolk-stalk apparatus leading into the spiral valve in the gut of a foetal *Galeus laevis* (Fig. 6 herein). He also gives us another diagrammatic figure (No. 7 herein) of the winding valve in a foetus of a non-placental (viviparous) "Spina piscis" (*Acanthias vulgaris*). Neither valve is described.

III. (2).—Perrault (1680) figured and briefly described the "scroll" valve of a *Galeus glaucus* (*Carcharias glaucus*). This is the first dissection and portrayal (Fig. 8 herein) on record so far as has been found of a non-screw-shaped valve in a shark, and ends our series for sharks.

A SPIRAL VALVE IN A GANOID

IV. (2).—Swammerdam (1673B) portrayed and briefly described for the first time the winding valve in a Sturgeon (Ganoid). This (Fig. 9 herein) is the first valve to be found in this study to have a central pillar or support.

There are reproduced herein in external view or in dissection 10 figures of spiral valves—9 in Elasmobranchs and 1 in a Ganoid. In addition, reference is

made to descriptions (without figures) of two valves in a shark and in a ray, respectively, making a total of 12.

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STUDIES IN THE LEGUMINOSAE. V. CYTOLOGICAL OBSERVATIONS ON *CROTALARIA*

By Earlene Atchison

Department of Botany, University of North Carolina, Chapel Hill, North Carolina

Crotalaria L. consists of 250–400 species, depending on the authority, of annual and perennial herbs, subshrubs and shrubs, the definitive character being inflated pods. Various species are commonly known as "rattleboxes" in the southeastern states. The genus occurs throughout the tropical and warm temperate regions of both hemispheres; the greatest number and diversity of species seem to be concentrated in tropical Africa, with outlying centers of variation in Southeastern Asia and Central America. Various species are of some interest as forage and cover crops, alkaloid and fiber sources. Baker (1914) has reviewed the taxonomic history and monographed the African species; Senn (1939), the North and Central American species. There is no complete monographic study of the Asiatic group. A new, complete treatment of the entire genus would be difficult, but desirable.

The cytological literature on *Crotalaria* contains few detailed studies. Eichorn (1937) described the mitotic cycle in *C. fulva* and *C. spinosa*. Kawakami (1930), Hagerup (1932), Ramanujam, Parthasarthy and Ramiah (1933), Breslavetz, Medwedwa and Magitt (1934), and Senn (1938) have reported chromosome numbers for various species. Sundar Rao (1943) (taken from Darlington and Janaki-Ammal, 1945) reported $n = 8$ for 10 species. Raghaven and Venkatasubban (1943), in a study of the unrelated Zingerberaceae, reported unpublished work on 5 species of *Crotalaria* which had been observed to have identical number and morphology. These lists, although covering 19 widely distributed species, contain only one number other than $n = 8$, *C. incana* with $n = 7$.

Cytological and growth habit studies for 16 additional species are included in the present paper.

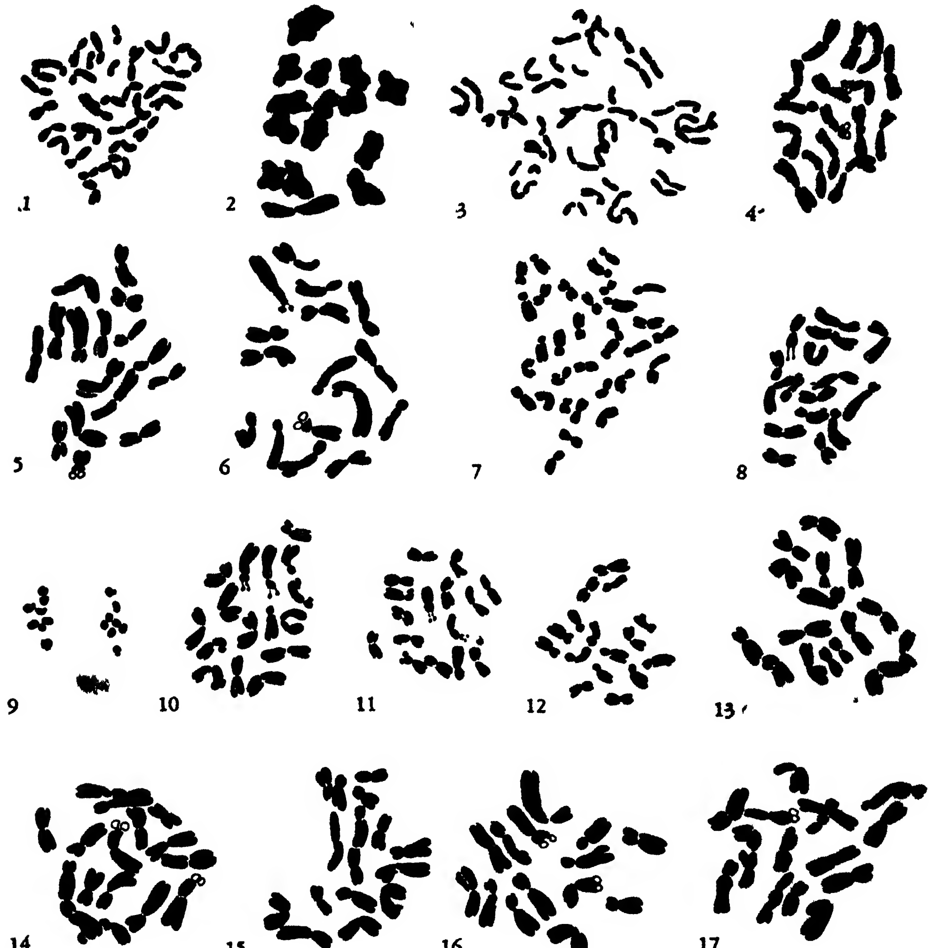
Chromosome number determinations (Figs. 1–17) have been made from acetic orcein leaf smears. Young leaves were prefixed for one hour in a saturated solution of paradichlorobenzene (Meyer, 1945). Meiosis was studied from direct acetic orcein smears of pollen mother cells.

Species were grown in experimental plots at The Blandy Experimental Farm, Boyce, Virginia, and at the Atkins Garden and Research Laboratory, Cienfuegos, Cuba.

General distribution, chromosome numbers, previous citations, and the present author's collection number are indicated in Table I. Where possible the species in Table I are grouped into Sections according to Baker (1914) and Senn (1939). Because of the general inaccessibility of cytological studies on *Crotalaria*, previous reports are summarized in the table.

The Asiatic, African, and South American species are principally diploids,

$2n = 16$, $n = 8$ chromosomes. Exceptions to this number are found in *C. incana*, $2n = 14$, from the world tropics, *C. pumila*, $2n = 32$, from South, Central and North America, and *C. pilosa* and its var. *Skutchii* from Central America. Other



FIGS. 1–17. Chromosomes of *Crotalaria*. Magnification, ×1500, except Fig. 9, ×600.

1. *C. pilosa* var. *Skutchii*, $2n = 32$. 2. MI, $n = 16$. 3. Trichome, $4n$ = ca. 64. 4. *C. spectabilis*, $2n = 16$. 5. *C. verrucosa*, $2n = 16$. 6. *C. Saltiana*, $2n = 16$. 7. *C. pumila*, $2n = 32$. 8. *C. maxillaris*, $2n = 16$. 9. AI, $n = 8$. 10. *C. intermedia*, $2n = 16$. 11. *C. ivantulensis*, $2n = 16$. 12. *C. Grantiana*, $2n = 16$. 13. *C. usaramoensis*, $2n = 16$. 14. *C. goreënsis*, $2n = 16$. 15. *C. lanceolata*, $2n = 16$. 16. *C. incana*, $2n = 14$. 17. *C. mucronata*, $2n = 16$.

$2n = 32$ species are found in the limited section of the genus which has extended into temperate North America; these will be discussed in a later paper.

C. incana apparently had an African center of origin; 52 of its congeners are listed from Angola alone. Senn (1938) suggests that $n = 7$ in this species arose

TABLE 1

Chromosome numbers in Crotalaria

SPECIES	DISTRIBUTION	*n*	2*n*	AUTHOR AND COLL. NO.
	Sect. I. Simplicifoliae Benth.			
C. pilosa Mill	W.I., C.A., S.A.		32	Atchison, 341
C. pilosa Mill. var. *Skutchii* Senn.	W.I., C.A., S.A.	16	32	Atchison, 340
C. Arenaria Benth.	E. Africa	8		Hagerup, 1932
C. spectabilis Roth.	Asia		16	Atchison, 327
C. juncea L.	Asia-Australia	8		Ramanujam *et al.*, 1933
			16	Breslavetz *et al.*, 1934
C. alata Ham.	Asia	8		Kawakami, 1930
• *C. retusa* L.	cos. Trop.	8	16	Kawakami, 1930
		8		Ramanujam *et al.*, 1933
C. verrucosa L.		8		Ramanujam *et al*, 1933
C. verrucosa L.			16	Atchison, 70
	Sect IV. Farctae Benth			
C. Saltiana Andr.	E. Africa		16	Atchison, 313
	Sect. V. Spinosa Bak.			
C. spinosa Hochst.	E. Africa		16	Eichorn, 1937
	Sect. VI. Eucrotalaria			
C. pumila Ortega	S U.S., C.A., S.A., W.I.		32	Atchison, 339
C. anagyroides HBK	W I., Mex., S A.	8		Kawakami, 1930
C. maxillaris Klotz.	E Africa	8	16	Atchison, 303
C. intermedia Kotschy	Africa		16	Atchison, 333
C. ivantulensis Welw.	Africa		16	Atchison
C. Grantiana Harms	Africa		16	Atchison, 323
C. Dilloniana Baker	Africa		16	Atchison
• *C. usaramoensis* Bak. fil.	E. Africa	8		Kawakami, 1930
C. goreensis, Guill. et Perr.	Africa		16	Atchison
C. lanceolata E. Mey.		8		Raghavan & Venkatasubban, 1943
			16	Atchison, 325
C. argyraea ? Welw.	Africa	8		Senn, 1938
C. obovata Don.	Africa	8		Hagerup, 1932
C. quinquefolia L.	Asia		16	Sundar Rao, 1943
C. laburnifolia L.	Ind., Phil.	8		Ramanujam *et al*, 1933
• *C. incana* L.	cos. Trop.	7		Senn, 1938
			14	Atchison, 337
C. mucronata Desv.	cos. Trop.	8		Senn, 1938
			16	Atchison, 328
	Sect. ?			
C. Valetonii Backer	E. Indies	8		Kawakami, 1930
C. fulva	Asia		16	Eichorn, 1937
C. usorensis		8		Raghavan & Venkatasubban, 1943
C. breviflora		8		Raghavan & Venkatasubban, 1943

through aneuploid reduction from an $n = 8$ ancestral form. Comparison of the chromosome morphology of *C. incana* with that of *C. mucronata* (Figs. 16 and 17), a closely related species, suggests that this reduction in number may have involved the loss of one pair of short chromosomes with median centromeres. *C. incana* contains 3 pairs of long chromosomes while *C. mucronata* contains only 2; *C. incana* contains only one pair of short chromosomes while *C. mucronata* contains 2. Such a reduction could occur through reciprocal translocation involving the loss of a centromere without loss of essential genetic material. Such translocations have been established as evolutionary mechanisms by Tobgy (1943).

C. pumila shows a wider tolerance to environmental variations than most of the related species. It is a weedy colonizer from warm temperate Argentina through the American tropics into warm temperate United States. In spite of this wide north-south distribution, however, *C. pumila's* limitation to this hemisphere suggests its origin as recent in comparison with its tropical relatives. The nearest morphological relative among the author's collections is *C. maxillaris* from east Africa. Pod development was stimulated, but no fertile seeds were matured by the cross *C. pumila* x *C. maxillaris*. There is little intraspecific variation in *C. pumila* as might be expected if the species were of hybrid origin. The only character with notable variation is pod number per raceme: Three seasons of experimental culture show that some collections constantly mature 3 pods on each raceme while others mature 4 to 8. It is possible that the positive qualities of a short season reproductive cycle, resistance to the *Crotalaria* moth, and prolific production of fruit are effects of gene duplication through increased chromosome number.

Neither *C. incana* nor *C. pumila* shows sufficient morphological divergence to be separated from Section Eucrotalaria.

Polysomic cells with ca. 64 and 90 chromosomes (Fig. 3) were found in the trichomes of leaves of 7 plants of *C. pilosa* var. *Skutchii*. Not only are mitoses usually absent from normal differentiated tissue, but this material had not been pretreated with either paradichlorobenzene or any other substance which might have had a c-mitotic effect. The author has no explanation of the stimulus for chromosome division in these cells; but suggests that the quantitative increase in chromatin, if not actual chromosome number, may be correlated with differentiation, as proposed by Huskins and Steinitz (1948). Castronova (1945) has encountered divisions with multiple chromosome numbers in seedlings of *Acacia*, also a legume, germinated under sterile conditions.

An inverse correlation between chromosome number and size is generally clear: Chromosomes of *C. incana*, $2n = 14$, are slightly larger than those of most of the $2n = 16$ species, while those of *C. pilosa* and *C. pumila*, $2n = 32$, are relatively smaller.

Cytological and morphological patterns among *Crotalaria* indicate that the genus is ancestrally tropical with a diploid number of $2n = 16$ chromosomes. Those species with variant chromosome numbers also show variation from the central group in either distribution or morphology.

Comparison of growth habits in tropical Cuba with those in the temperate United States discloses notable specific modification. *C. juncea*, *C. spectabilis*, *C. mucronata*, *C. incana*, and *C. usaramoensis* survive as herbaceous annuals in temperate regions, but become woody and shrubby if given the prolonged tropical growing season and higher minimum temperatures. *C. intermedia* is a perennial herb in either climatic region. *C. lanceolata*, *C. maxillaris*, *C. pumila* and *C. retusa* are annual herbs in either region. The capacity for formation of woody tissue seems to be characteristic of some species, with expression dependent on environment. In other species woodiness is apparently totally absent.

SUMMARY

Somatic chromosome studies are reported for 16 species of *Crotalaria* L. which are new to the literature. The most frequently observed number is $2n = 16$. This is accepted as the basic diploid complement, and it is suggested that morphological and distributional changes have accompanied aneuploidy in the case of *C. incana*, tetraploidy in the cases of *C. pumila* and *C. pilosa*.

Perennial and annual growth habit are apparently dual capacities, with expression dependent on environment, in several species; in others habit is strictly limited by heredity.

Polysomic cells were observed in the trichomes of *C. pilosa*.

The author is grateful to Dr. Orland E. White for suggestions concerning the manuscript, and to the many individuals who have provided seed for these and subsequent studies.

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THE EFFECT OF A VITAMIN A DEFICIENT DIET ON THE NATURAL AND ACQUIRED RESISTANCE OF MICE TO INFECTION WITH *TRICHINELLA SPIRALIS*

By John E. Larsh, Jr. and Hazel B. Gilchrist

Department of Parasitology, School of Public Health, University of North Carolina, Chapel Hill, North Carolina

It has been demonstrated by certain workers (McCoy, 1934; Motomura and Umezu, 1936; Lawler, 1941) that animals placed on diets deficient in vitamin A show a lowered resistance to certain of the parasitic nematodes. McCoy was able to show the specific role of this vitamin in the development of resistance in rats to *Trichinella spiralis*. Young rats started on a vitamin A deficient diet when 25 to 27 days old showed a markedly lowered resistance to infection as early as 2 or 3 weeks. Those on the deficient diet also failed to develop any resistance to a second infection whereas the controls became immune.

The mouse has been shown to be a suitable host in experimental trichiniasis (Culbertson, 1942; Larsh and Hendricks, 1949; Larsh and Kent, 1949; Hendricks, in press; and others), but no reports were found dealing with the effect on their resistance of a vitamin A deficient diet. It was, therefore, the purpose of the present work with mice to determine the effect of such a diet on natural resistance and on resistance following repeated infections.

MATERIALS AND METHODS

The experimental methods for infecting animals and for recovering *T. spiralis* adults and larvae were the same as those reported in detail in an earlier paper (Larsh and Kent, 1949). The vitamin A deficient diet for the preliminary experiments was a rat diet used by Lawler (1941). This diet (Diet I) consisted of the following: casein (vitamin-test), 18.0 per cent; irradiated yeast, 5.0 per cent; corn starch, 67.4 per cent; cottonseed oil, 5.0 per cent; $CaCO_3$, 1.5 per cent, KCl, 1.0 per cent; NaCl, 0.5 per cent; $NaHCO_3$, 0.7 per cent; MgO, 0.2 per cent; and Fe citrate, 0.5 per cent. Fifteen drops of activated ergosterol (10,000 U.S.P. vitamin D units per gram) were added per kilo of mixture. The control diet was identical except for the addition of 1.0 per cent cod-liver oil. It was unsatisfactory to feed the diets in powdered form because of waste and contamination. To prevent this, plain bacto-agar (Difco) was melted and added to the powdered diets to make a mixture approaching the consistency of a solid stock diet. The details of this technique are as follows. All of the ingredients were carefully weighed and mixed thoroughly in the preparation of the powdered diets. The A deficient and the control diets were prepared separately, usually in 3 kilogram lots. For this amount, 60 grams of plain bacto-agar were dissolved in 2100 cc of distilled water in a large flask by autoclaving for 10 minutes. It was allowed to cool to a temperature of 56°C before being added to the dry ingredients. The

resulting mixture was kneaded thoroughly, then spread on a clean flat surface to a thickness of about one-half inch; and after standing for 20 to 30 minutes at room temperature, it was cut into squares and stored in a deep freezer. For ease of handling, the food was stored in paper bags containing 100 grams each.

The results obtained in the preliminary experiments following use of this rat diet were difficult to interpret. Therefore, it was thought advisable to repeat the work using a diet more suitable for mice. With helpful suggestions from Dr. H. P. Morris (personal communication) of the National Cancer Institute the following vitamin A deficient diet (Diet II) was formulated: casein (vitamin-test), 15.0 per cent; irradiated yeast, 5.0 per cent; cornstarch, 43.0 per cent; sucrose, 15.0 per cent; fat (Crisco), 18.0 per cent; and salt mixture (Jones and Foster, 1942), 4.0 per cent. The control diet was identical except that the amount of Crisco was lowered to 15.0 per cent and 3.0 per cent cod-liver oil was added. Because of a difference in consistency of Diets I and II, only 30 grams of bacto-agar dissolved in 1000 cc of water were needed for 3 kilograms of dry ingredients of Diet II. The preparation of this diet was the same as that described for Diet I except that it was necessary to refrigerate the diet for about one hour before it could be cut into squares.

The age of the mice at the beginning of the experiments varied from 3 to 5 weeks; the age for each experiment is given below. The mice were matched according to sex and approximate weight and divided into 2 groups, experimentals (on A deficient diet) and controls (on diet with cod-liver oil). In all cases the mice were allowed food and water *ad libitum*. The food was contained in wire feeding baskets suspended from the tops of the cages (Larsh, 1947), and sufficient amounts were added daily to prevent the accumulation of dried and hardened portions. A record was kept for each experiment of the weight change of each group of mice and of their daily food consumption from the beginning of the experiment until time of autopsy. Since these records showed no significant difference for the mice on the two diets, the data are omitted from the discussion of the experiments.

Student's "t" test was the instrument used to determine the statistical significance of the observed differences in numbers of parasites recovered from the experimental and control groups. A probability greater than 5 was not considered to be significant.

EXPERIMENTAL RESULTS AND DISCUSSION

I. Preliminary experiments to determine the effect of a vitamin A deficient diet (Diet I) on the natural and acquired resistance of mice to infection with T. spiralis

A. Natural resistance.—A series of 7 experiments was completed. All the groups of animals were 5 weeks old when put on the experimental and control diets, with the exception of those of experiment 7 in which the mice were 4 weeks of age. The animals were kept on the diets for varying lengths of time (from 6 weeks in experiments 1, 3, and 5 to 14 weeks in experiment 7) before receiving a single

infection. They were continued on the diets until the time of autopsy. The size of the infection varied from 300 larvae in experiments 1 and 2 to 900 larvae in experiments 5, 6, and 7. Seven days after infection the mice were killed and counts made of the adult *Trichinella* recovered from the small intestine. The results are shown in Table 1.

The difference in the number of worms recovered from the mice of the A deficient groups and control groups is not of statistical significance, except for experiments 1 and 5 (189.0 and 148.7, and 516.0 and 384.1, respectively). It is, therefore, difficult to interpret these findings. It is worth noting, however, that in experiments 2 and 6, similar to 1 and 5 respectively, there was no significant difference in the number of worms recovered, despite the fact that the mice were exposed to the deficient diet for 3 weeks longer than those of experiments 1 and 5.

B. Acquired resistance.—In this experiment, experimental and control mice were put on their respective diets when 4 weeks old and given an initial stimulating infection 4 weeks later. Three additional stimulating infections of 300 larvae each were given at 2-week intervals. For each infection, 2 additional mice were given the infecting dose and killed 7 days later to check on the viability of the larvae used. In every case, the average recovery of adult worms from these viability controls was about that expected from the dose. The fourth stimulating infection was followed one week later with an infection of 900 larvae to test for the presence of resistance acquired as a result of the stimulating infections. This final infection is called the challenging infection. At the time of this infection, two groups of controls which were of the same age as the above mice and had been fed the A deficient and control diets but had not received the stimulating infections were also given the infection of 900 larvae. These mice were used to check on the effect of the diets on natural resistance, as in the previous experiments. One week after the challenging infection was administered, all of the animals were killed and counts were made of the adults recovered from the small intestines. The numbers of larvae from the muscles of the animals given the 4

TABLE 1

Showing the numbers of adult T. spiralis *recovered from mice kept on an A deficient diet (Diet I) and from controls killed seven days after one test infection*

EXP NO.	AGE WHEN PUT ON DIET	TOTAL TIME ON DIET	NO. LARVAE IN INFECTING DOSE	MICE ON A DEFICIENT DIET			MICE ON CONTROL DIET			PROBABILITY
				No. mice	Adults recovered: Ave. no	Adults recovered: Per cent	No. mice	Adults recovered: Ave no	Adults recovered: Per cent	
	wks.	*wks.*								
1	5	6	300	6	189.0	63.0	6	148.7	49.6	<.05
2	5	9	300	7	191.4	63.8	6	145.7	48.6	> 05
3	5	6	600	6	305 7	50.9	6	280.7	46.8	> 05
4	5	9	600	6	318.3	53.1	6	308.8	51.5	>.05
5	5	6	900	7	516.0	57.3	7	384.1	42.7	<.05
6	5	9	900	7	434.3	48.3	6	379.8	42.2	>.05
7	4	14	900	11	321.0	35.7	9	341.3	37 9	> 05

stimulating infections were determined by dilution counts. The results of all of these counts are shown in Table 2.

TABLE 2

Showing the numbers of T. spiralis *adults and larvae recovered from mice killed 7 days after a challenging infection. The animals were kept on the diets from the age of 4 weeks until autopsy*

MICE ON A DEFICIENT DIET			MICE ON CONTROL DIET		
Mouse no.	No. adults in small intestine	No. larvae in muscles	Mouse no.	No. adults in small intestine	No. larvae in muscles
A. Mice given 4 infections of 300 larvae each at 2-week intervals followed one week later by a challenging infection of 900 larvae					
1	723	50,800	1	503	48,600
2	606	28,600	2	381	57,000
3	664	45,200	3	102	78,000
4	597	59,000	4	320	96,000
5	574	38,000	5	631	82,000
6	558	88,000	6	191	20,200
7	371	62,000	7	443	89,000
8	536	42,200	8	346	43,000
9	428	58,000	9	483	60,000
10	580	100,000	10	273	104,000
11	663	60,000	11	224	36,000
12	487	19,000	12	332	40,400
13	623	30,000	13	172	38,000
14	422	41,600	14	126	38,000
15	718	24,500			
16	508	26,000			
Ave. no	566.1	48,306		323.4	59,300
Percentage	62.9			35.9	
B. Mice given only the challenging infection of 900 larvae					
1	380		1	419	
2	308		2	337	
3	346		3	364	
4	375		4	336	
5	371		5	317	
6	275		6	335	
7	355		7	380	
8	176		8	264	
9	353		9	320	
10	305				
11	287				
Ave. no.	321.0			341.3	
Percentage	35.7			37.9	

There is a significant difference in the numbers of adult worms recovered from the experimental and control mice which had been given the stimulating infec-

tions (A). Those on the A deficient diet averaged 566.1 as compared with 323.4 for the control mice. However, the difference in the number of adults from these controls (A, average 323.4) and from controls given only the challenging infection (B, average 341.3) is not significant. Therefore, no demonstrable resistance was developed as a result of the stimulating infections. This suggests that the significantly greater number of worms in mice of the A deficient group given these stimulating infections than in their controls was due to a breakdown in natural resistance. There is no explanation for the failure of the control mice to develop acquired resistance in this experiment, as previous work has demonstrated the acquisition of resistance in mice on a diet of Purina dog checkers (Larsh and Kent, 1949). This suggests that the rat diet used in the present work, although maintaining the mice in apparently good condition, may not have been satisfactory in supplying factors needed as a result of the stress of repeated infections. In this respect it is worth noting that McCoy (1934) was able to demonstrate in rats fed a similar diet that the controls became immune after two infections whereas those on the A deficient diet failed to develop resistance.

There is no significant difference in the number of adults recovered from the mice on the A deficient diet given only the challenging infection (B) and from their controls. Thus the natural resistance of the animals was not altered to a demonstrable degree by feeding the deficient diet for this period of time. This agrees with most of the experiments of the previous section (Table 1). On the basis of the present experiment, therefore, it would appear that the combination of the A deficient diet and repeated infections produced the breakdown in resistance reported above (A of Table 2).

The numbers of larvae recovered from the mice of the A deficient group (A, average 48,306) and their controls (average 59,300) do not differ significantly. Thus these results differ from those of adult counts in which the mice on the deficient diet harbored significantly greater numbers than controls. This could mean that the diet inhibited the production of larvae by the females in the intestine, or that resistance to the larvae during migration to, or life within, the muscles was not interfered with by this diet to the same degree as resistance against the adults. If the latter could be proved by further work, it would be of real interest in view of the fact that different antibodies have been demonstrated to operate against the adults in the intestine and the larvae in the musculature (Oliver-Gonzalez, 1941).

A final experiment was planned which was hoped would clarify certain of the inconsistencies of the above results. The most serious of these was the failure of control mice to develop acquired resistance (Table 2), a phenomenon demonstrated in previous work in mice on a different diet. The diet was changed from the above, used mostly for rats, to one more suitable for mice.

II. A final experiment to determine the effect of a vitamin A deficient diet (Diet II) on the natural and acquired resistance of mice to infection with T. spiralis

A. Natural resistance.—In this experiment, mice were weaned at 3 weeks of age, divided into two groups, and kept on their respective diets for 11 weeks

before being given a test infection of 200 larvae. One week later they were killed and counts made of the adult worms recovered from the small intestine (B of Table 3). There is no significant difference in the number of worms recovered from the experimental and control groups (average, 106.5 and 107.9 respectively).

TABLE 3

Showing the numbers of adult T. spiralis *recovered from mice killed 7 days after a challenging infection. The animals were kept on the diets from the age of 3 weeks until autopsy*

MICE ON A DEFICIENT DIET		MICE ON CONTROL DIET	
Mouse no.	No. adults in intestine	Mouse no.	No. adults in intestine
A. Mice given 2 infections of 200 larvae each at 4-week intervals followed 4 weeks later by a challenging infection of the same size			
1	77	1	79
2	65	2	52
3	60	3	68
4	55	4	54
5	50	5	48
6	88	6	54
7	80	7	76
8	71	8	67
		9	50
		10	73
Ave. no.	68.2		62.1
Percentage	34.1		31.1
B. Mice given only the challenging infection of 200 larvae			
1	119	1	124
2	80	2	84
3	87	3	110
4	89	4	97
5	137	5	81
6	123	6	119
7	90	7	94
8	106	8	83
9	129	9	136
10	126	10	118
11	86	11	127
		12	122
Ave. no.	106.5		107.9
Percentage	53.3		53.9

This is in agreement with the results of the majority of the preliminary experiments (Table 1). However, only 4 weeks on the same diet used in the above preliminary experiments were necessary to produce in young rats a lowered resistance to *Strongyloides* (Lawler, 1941). McCoy (1934) and Motomura and

Umezu (1936) also found that rats on a vitamin A deficient diet for a short time showed a lowered resistance to *T. spiralis*. This suggests a host difference in the effect of a vitamin A deficient diet on the natural resistance to *T. spiralis*.

B. Acquired resistance.—Three week old mice were weaned, divided into two groups, and fed their respective diets until the end of the experiment. When they were 5 weeks old, the mice were given an initial stimulating infection of 200 larvae, followed 4 weeks later by a second infection of the same size. In both cases, mice were included to check the viability of the larvae used. Four weeks after the second stimulating infection, a challenging infection of 200 larvae was administered. This was also given to two other groups of mice the same age on the same diets that had been treated as the above mice except that they did not receive the stimulating infections (B of Table 3). The mice were killed one week after the challenging infection and counts of adults made (A and B of Table 3).

The difference in the number of worms recovered from mice on the deficient diet (A, average 68.2) and from controls (A, average 62.1) is not of statistical significance. The mice on both diets had developed resistance to reinfection as brought out by comparing the numbers of worms recovered from them (A) with the much higher counts for the mice given only the challenging infection (B); the latter on the deficient and control diets, respectively, harbored an average of 106.5 and 107.9 worms. The probability of this difference occurring by chance is less than one in 100 similar experiments, hence highly significant. The development of acquired resistance here supports the above suggestion that failure to do so by controls in the previous experiment (Table 2) might have been due to inadequacy of the diet used. It is clear from the present results that the deficient diet as used did not interfere either with natural resistance or with the development of acquired resistance.

The findings of this final experiment, therefore, show that the need for vitamin A in the operation of resistance to *T. spiralis*, if such need exists, is certainly not of the same magnitude for mice as demonstrated earlier for rats.

SUMMARY

Preliminary experiments were performed in an attempt to determine the effect of a vitamin A deficient diet (Diet I), designed primarily for rats, on the natural and acquired resistance of mice to *Trichinella spiralis*. The results of most of the experiments indicated that natural resistance was not affected by the deficient diet even following prolonged feeding. After repeated infections, the control mice failed to develop resistance as they had in previous work on a different diet. Since the animals on the experimental diet harbored significantly greater numbers of worms, it suggested a breakdown in natural rather than in acquired resistance. Earlier workers using a similar deficient diet in experiments with rats showed that the controls became immune after reinfection whereas those on the deficient diet failed to develop demonstrable resistance. This discrepancy in results for the controls used in the separate studies suggested that the diet was not suitable for mice, so that a final experiment was performed after changing diets (Diet II).

The natural resistance of the mice was not affected after 11 weeks on the deficient diet (Diet II), as the number of adult worms recovered from them following infection was similar to that from controls. Mice on the deficient diet developed about the same degree of acquired resistance as the controls after two stimulating infections. Thus this deficient diet did not interfere with the operation of either natural or acquired resistance. The fact that the controls developed resistance following repeated infections supports the above view that the rat diet was unsatisfactory for this work. The findings of the final experiment with a suitable diet for mice show that the need for vitamin A in the operation of this resistance, if such need exists, is certainly not of the same magnitude for mice as demonstrated earlier for rats.

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NOTES ON *ISOETES* IN NORTH CAROLINA[1]

By A. E. Radford

Department of Botany, University of North Carolina
Chapel Hill, North Carolina

While doing field work on the vascular aquatic plants of North Carolina during the spring and summer of 1949, I collected specimens of *Isoetes* from bogs, pools, lakes, and streams in twenty-nine counties, from Tyrrell to Cherokee.

Isoetes is fairly abundant in all of the mountain counties. It is very common in the Hendersonville-Brevard area in the clear, cool lakes and pools with black mud bottoms. The leaves are broken off by muskrats and other animals and float on the surface, forming a mat so thick that it is a nuisance to swimmers

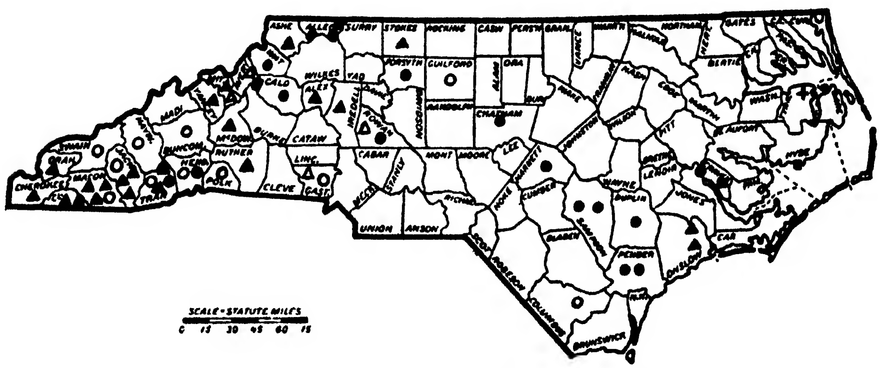

Fig. I. Distribution of *Isoetes* in North Carolina

● *Isoetes Engelmanni* A. Br. as reported in this paper.
▲ *I. Engelmanni* var. *caroliniana* A. A. Eaton as reported in this paper.
+ *I. saccharata* Engelm. as reported in this paper.
○ *I. Engelmanni* A. Br. as reported by Blomquist and Correll.
△ *I. Engelmanni* var. *caroliniana* A. A. Eaton as reported by Blomquist and Correll.

and fishermen. In Lake Sega near Brevard and in Wolf Lake near Hendersonville, the leaves have to be cleaned from the lakes regularly. Many unsuccessful attempts have been made to exterminate it in various lakes. The Country Club Lake at Highlands is drained every winter to keep down the vegetation, but *Isoetes*, being amphibious, survives and is very abundant on the bottom of the lake.

Isoetes has a scattered distribution in the piedmont counties and is not very abundant where found. One exception is Peeler's Lake in Rowan County, a very clear, clean lake for the piedmont area, where it is plentiful. On the coastal

[1] This work was supported in part by a grant from the Carnegie Foundation for the Advancement of Teaching and in part by a scholarship from the Highlands Biological Station, Highlands, North Carolina.

plain it is found in the slow-moving streams and on the black muddy stream banks in the overflow area. No *Isoetes* was found in or near the highly acid "black water" streams and ponds of the coastal plain or mountains.

Specimens found in bogs were more robust than those growing in ponds and lakes. Some of the bog plants had leaves up to two feet long, and corms from 1½ to 2 inches in diameter.

In the Alligator River at Ft. Landing where the river opens into Albemarle Sound, within the tidal area, I found *Isoetes saccharata* Engelm. growing on *Sagittaria* rhizomes. As far as is known, this is the first record of this species in North Carolina.

Isoetes has now been reported from every mountain county of North Carolina except Madison (see Fig. I, showing data on my collections, together with those reported by Blomquist and Correll in Journ. Elisha Mitchell Sci. Soc. **56**: 104–105, 1940). Closer observation will doubtless show that *Isoetes* is more widely distributed in the coastal plain than is commonly thought. As more and more of the many farm ponds in the state become stabilized, *Isoetes* should have a greater distribution in North Carolina.

Dr. Norma E. Pfeiffer very kindly determined several specimens, among them *Isoetes saccharata* Engelm. from Tyrrell County.

Listed below are my collections of *Isoetes* from North Carolina made during the spring and summer of 1949. These specimens are deposited in the Herbarium of the University of North Carolina.

Isoetes saccharata Engelm.

Tyrrell Co. Shallow brackish water, Alligator River. Ft. Landing. #4624.

Isoetes Engelmanni A. Br.

Alleghany Co. Upper end of Lake Louise near road at Roaring Gap. #4926.
State Fish Hatchery pond at Roaring Gap. #4069.
Avery Co. Submerged in Wildcat Lake southwest of Banner Elk. #4976.
Caldwell Co. Farm pond near N.C. #18, 4 miles north of Lenoir. #4962.
Chatham Co. Bog approximately 3 miles south of Chapel Hill. #3081.
Craven Co. Core Creek near U.S. #70. #4435.
Duplin Co. Black mud on bank of Limestone Creek near N.C. #24, west of Beulaville. #5056.
Forsyth Co. Weaver's Lake near U.S. #421, west of Kernersville. #4964.
Harnett Co. Stuart Creek near U.S. #15A, 1 mile north of Erwin. #4013.
Henderson Co. Wolf Lake near Crab Creek Rd., 5 miles west of Hendersonville. #4838.
Pender Co. Sluggish stream near N.C. #53, 3 miles east of intersection of N.C. #53 and U.S. #421. #4007.
Moore's Creek near N.C. #53, west of Burgaw. #4012.
Rowan Co. Peeler's Lake near U.S. #52, north of Granite City. #4912.
Sampson Co. Bog on Six Runs Creek near U.S. #421. #4008.
Muddy bank of Six Runs Creek near N.C. #24, west of Turkey. #5059.
Transylvania Co. Eagle's Nest Camp Lake near town of Pisgah Forest on U.S. #64. #4832.
Watauga Co. Snyder's Lake at Blowing Rock. #4945.

Isoetes Engelmanni var. *caroliniana* A. A. Eaton.

Alexander Co. Black "soupy" bog in pigpen near N.C. #16, 1 mile north of Schneider's Mills. #4973.
Alleghany Co. Shallow water at Roaring Gap State Fish Hatchery. #4930.
Ashe Co. Shallow water in C. D. Bare's pond, 2 miles northeast of Glendale. #4939.
Cherokee Co. Pool in old marble quarry at Marble. #4810.
Clay Co. Bog near U.S. #64, 12 miles east of Hayesville. #4799.
Temporary roadside pool near Buck Creek bridge on U.S. #64. #4798.
Craven Co. Batchelder's Creek near U.S. #70. #4435.
Graham Co. Bog on Rock Creek near forestry road to Andrews, 1½ miles south of Robbinsville. #4813.
Iredell Co. Bog 2.2 miles east of junction of N.C. #115 and N.C. #901. #2647.
Jackson Co. Lake Sapphire east of Cashiers. #4772.
Cashiers Lake at Cashiers. #4754.
Upper Lake at High Hampton. #4820.
Macon Co. Mirror Lake at Highlands. #4788.
Lake Sequoyah at Highlands. #4786.
Country Club Lake at Highlands. #4778.
McDowell Co. State Fish Hatchery pool at Marion. #4884.
Mitchell Co. Estes Pond near N.C. #26, 1½ miles south of Spruce Pine. #4958.
Onslow Co. Black muddy creek bank near U.S. #258, 1 mile north of junction of N.C. #53 and U.S. #258. #5051.
Black mud on bank of New River near U.S. #258, northwest of Jacksonville. #5053.
Rutherford Co. McCall's Lake near N.C. #26, 2 miles east of Burke county line. #4896.
Stokes Co. Lake in Hanging Rock State Park. #3081.
Transylvania Co. Rockhouse Camp pool near U.S. #276, 4 miles south of Brevard. #4827.
Lake Sega near Brevard. #4825.
Yancey Co. Bog near N.C #197, 1 mile north of Pensacola. #4957.

ACTINOPLANES, A NEW GENUS OF THE ACTINOMYCETALES[1]

By J. N. Couch

Department of Botany, University of North Carolina
Chapel Hill, North Carolina

Plates 10–12 and One Text Figure

In a recent paper (1949) the writer announced the discovery of sporangia and motile spores in a group of organisms related to *Streptomyces* and *Micromonospora*. Although these new forms seemed very definitely to belong to a new genus, the writer hesitated to establish one until authentic material of *Micromonospora chalceae* had been studied and until the "flagella" on the motile spores could be stained by a standard, bacterial flagella stain.

Recently there have been received from Dr. H. L. Jensen, now in Denmark, four strains "fairly representative" of *Micromonospora chalceae*, the type species of that genus, and these have proved to be quite distinct from the present forms, although closely related. Both *Actinoplanes* and *Micromonospora* grow slowly, forming a slimy-appearing, brilliantly colored mycelium on most agars. Some species or strains of *Micromonospora* which sporulate slowly or sparingly on certain agars are indistinguishable in gross appearance from some strains of *Actinoplanes*. The two genera, however, are readily distinguished. *Actinoplanes*, though a slow grower, is more vigorous than *Micromonospora*. The latter is reported to have non-septate hyphae and does not form a palisade layer at the surface of the agars, while *Actinoplanes* has septate hyphae and forms a distinct palisade layer on certain agars. They are most easily separated by their reproductive structures. In most species of *Micromonospora* the botryoid clusters of microspores are formed in such enormous quantities as to give the surface of the agar a blackish appearance. The only conidia so far observed in *Actinoplanes* are not in botryoid clusters. The most striking difference is that in *Actinoplanes* (except in coll. D.S. 22 and D.S. 34) sporangia and planospores are formed, while such structures have not been observed in *Micromonospora*. It may be of some significance that in *Micromonospora* the microspores are always formed within the medium and never in the air (Ørskov, 1923), while in *Actinoplanes* the sporangia and conidia are always formed at the surface in the air. The botryoid clusters of microspores of *Micromonospora* are shown on Plate 12.

The present genus resembles *Streptomyces* in the septate mycelial hyphae, and in the formation of palisade hyphae within the agar in at least two species of *Streptomyces* and in all species of *Actinoplanes*. In *Streptomyces* the conidia are formed in chains which in some species are arranged in spirals. It is of interest to note that in certain species of *Actinoplanes* the mature spores are usually

[1] **This work was made possible by a grant from the Carnegie Foundation for the Advancement of Teaching, which enabled the writer to employ Mrs. Alice R. Giles to do the culture work.**

arranged in spirals within the sporangia. The conidia in *Streptomyces* are about the same size and shape as are the planospores of *Actinoplanes*. The most striking differences between these two genera are the production in *Streptomyces* of a conspicuous aerial mycelium with abundant conidia while in *Actinoplanes* aerial mycelium is lacking except in one atypical species (D.S. 22 and 34) and conidia are few or lacking and the production in the latter of sporangia and swimming spores.

Certain species belonging to this genus or related to it have apparently been seen and described in part previously. At the Mycological Society meetings in New York in 1949, after seeing the writer's lantern slides and hearing the talk, Dr. J. S. Karling remarked that he had collected these forms many times, and that Miss Johanson had described a species belonging here under the name *Myceliochytrium fulgens* (1945). Miss Johanson interpreted this new genus as a polycentric chytrid and included it tentatively in the Cladochytriaceae. It has now been generally accepted that the structure and action of the motile cells are of the greatest importance in determining relationships in these lower fungi. Miss Johanson describes the swimming spores of her fungus as being posteriorly uniflagellate and structurally similar to the swimming spores of most known chytrids. However, as reported by the writer (1949) the motile spores of the present group are unlike those of any fungus but rather more like those found in certain bacteria. Thus the genus *Actinoplanes* differs from *Myceliochytrium* in the most critical feature. Now it is possible that Johanson's organism is correctly described and that it is a true chytrid with posteriorly uniflagellate swimming spores. If this is the case, her organism would be a true member of the lower Phycomycetes, and the rather striking similarities in mycelium and sporangia between her genus and the forms treated here would merely be another example of parallel development in two distantly related groups. It is more likely however that her description was drawn up from mixed material and that the swimming spores which she described as posteriorly uniflagellate and structurally similar to those of the chytrids actually belonged to a small true chytrid which was being carried on in her leaf cultures with the *Actinomyces*-like forms. There seems little doubt that the organisms described in the present paper were seen and partly described by Miss Johanson. The question, therefore, arises as to what name to use for these new forms? Since the name *Myceliochytrium* appears to apply to mixed material (a fungus and an Actinomycete), it can hardly be considered as valid. If on the other hand her material was not mixed, then the name *Myceliochytrium* stands as valid but applies to an organism with posteriorly uniflagellate swimming spores and hence quite distinct from the forms treated here.

The character of the flagella on the swimming spores is still uncertain. Dark-field observations have been repeated, using a Zeiss cardioid condenser, a ×35 oil immersion objective, and an arc lamp. The swimming spores were put in a 0.25 per cent solution of Methocel of the 15 cps viscosity recommended by Pijper (1947) as most suitable on the whole for viewing the flagella of bacteria. The spores were slowed down somewhat but no flagella were visible.

Stained preparations gave conflicting results. If killed with the fumes of 1 per cent osmic acid solution and stained with gentian violet a small percentage of the spores showed structures which might be flagella, one to a spore as reported in the former paper. Mr. W. J. Koch, graduate student in this department, using a bacterial flagella stain (Lee's method) has been able to demonstrate several "flagella" on each spore (Plate 10, fig. 1). These structures appear to be attached at the anterior end of the spore, perhaps bending backward as the spore is in motion. By using this same method, Mr. Koch was able to make very nice preparations showing typical flagella on certain rod-shaped bacteria. The assumption that these appendages on the spores of *Actinoplanes* are the organs of locomotion is of course open to doubt. From studies so far, it appears that the motile cells of these new forms are unlike those of any of the Phycomycetes but rather more like the bacteria.

Up to the present, thirteen apparently new forms have been isolated from soil collections. Since these do not fall into any known genus of the Actinomycetales, a new genus and the species upon which it is based are being described herein. In a later paper the remaining species will be described.

ACTINOPLANES NEW GENUS

Mycelium formed in water on a variety of plant and animal parts, also in various nutrient solutions and on various agars, usually brilliantly colored, pink, orange, etc., rarely nearly hyaline or dark brown. Aerial mycelium lacking as a rule, formed in certain species and then much as in *Streptomyces*. Surface on agar smooth or bumpy or convoluted, usually moist and shiny, rarely pulverulent. On boiled leaves in water, forming a very inconspicuous mycelium which grows in tufts and fringes around the edge of the leaf and also in tufts over the upper surface, giving the leaf a speckled appearance. Hyphae delicate, branched, sparingly septate; on agar, of two distinct forms, horizontal and vertical, the latter in some species making a compact palisade layer at the surface. Sporangia present usually abundant, borne at the surface on the palisade hyphae in contact with air, spherical, subspherical, or irregular in shape. Spores usually arranged in coils in the sporangia, discharged at maturity when flooded with water, spherical to cylindrical, small, with a single, minute globule; swimming vigorously or in some species non-motile. Flagella not certainly visible in living material, staining as in certain bacteria, several apparently attached at the apical end. Conidia formed in some species but not in botryoid clusters as in *Micromonospora*.

Aerobic; Gram positive and liquefying gelatin (Knox).

Sapropytic in a variety of soils and perhaps also in aquatic habitats.

Actinoplanes philippinensis n. sp.

Plates 10 and 11 and Text Fig. 1

On boiled leaves of grass (*Paspalum*) in water, forming a very delicate, hyaline to pinkish mycelium which grows in tufts and fringes around the entire edge of the piece of leaf and also in places over the upper surface, giving the leaf a speck-

led appearance; hyphae of uneven diameter, 0.5–1.5μ thick, branched, sparingly septate. Sporangia formed abundantly on grass after about ten days, also formed on certain agars, spherical to subspherical, usually on unbranched stalks, 8.4–27μ thick, most about 16μ thick; spores at maturity arranged in coils, about 1–1.2μ thick and with a single hyaline to yellowish globule, discharged through a pore or by the partial dissolution of the sporangial wall and swimming vigorously; flagella as described for the genus. Conidia formed in compact clusters of 12–20 on blocks of nutrient agar transferred to water, about 2 x 8–12μ, bent and with 5–7 constrictions.

On potato dextrose agar, growth vigorous, 1.8–2.2 cm. in diameter in 6–8 weeks (temp. 16–19°C.); margin 2–3 mm. wide, flat; central area elevated 2–3 mm. above the agar, convoluted, very tough in texture, composed of densely compacted, intertwined hyphae; color darker than on other agars, at first near

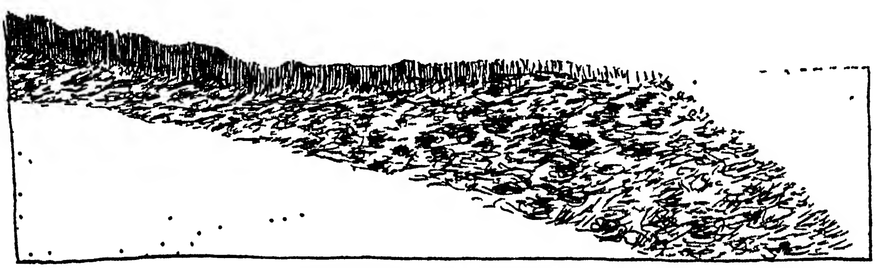

FIG. 1. Diagrammatic sketch of section of *Actinoplanes philippinensis* on Czapek's agar, Aug 29, 1949 ×8 approx The vertical lines at top represent palisade hyphae (bearing sporangia at left), the irregular lines represent the intramatrical, entangled, horizontal hyphae, the dotted area, agar

apricot-orange,[2] then mahogany red, chestnut, or cinnamon-rufous; mycelium giving off a diffusible pigment which darkens the surrounding agar. Palisade hyphae distinct in the non-convoluted region, forming a lattice work with the thinner, horizontal threads, becoming less distinct in older parts, many of the upright threads forming at the tip one sporangium each.

On nutrient agar, growth fair, about 1 cm. in diameter in 6–7 weeks (temp. 16–19°C.); margin 2–4 mm. wide, flat; center slightly elevated; color orange to cinnamon-rufous. Palisade hyphae not distinct.

On Krainsky's dextrose asparagin agar, growth vigorous, 1.6–2 cm. in diameter in 6–9 weeks (temp. 16–19°C.); margin narrow, flat; center up to 2 mm. high, convoluted; color ferruginous. Palisade hyphae distinct in flat area; sporangia formed over part of the palisades.

On Czapek's agar (1.5% agar), growth poor, 0.3–0.4 cm. in diameter after 7–9 weeks (temp. 16–19°C.), mostly submerged; center slightly elevated, rough; color cinnamon to tawny. Palisade hyphae very distinct, rarely branched, thicker than the much-branched, coiled and twisted hyphae; many sporangia formed in certain areas of the palisade hyphae.

[2] All colors are from Ridgway's *Color Standards and Nomenclature*.

On Czapek's agar with glycerine in place of sucrose, growth only slightly better than on Czapek's agar, 0.5 cm. in diameter in 7–8 weeks (temp. 16–19°C.); surface elevated, convoluted, no flat margin; color clay, cinnamon-rufous to darker; mycelium giving off a diffusible pigment which darkens agar as in P.D.A. No distinct unbranched palisade hyphae, upper layer thick, composed of upright but not vertical, branched, entangled hyphae. Upright hyphae thicker than the more entangled horizontal ones. No sporangia seen.

On Czapek's broth in flask, growth good, many floating and submerged patches after 6 weeks (temp. 20–23°C.), semi-globose, varying in size from almost invisible to 2 mm. thick; color bittersweet orange; composed of palisade hyphae on upper surface and much-entangled, branched and twisted hyphae below. Many sporangia formed on the palisade hyphae.

From a very small quantity of soil (coll. no. P15) sent to me by Lieutenant W. Lane Barksdale from the Philippine Islands in 1945; first seen in February 1948.

This species is characterized by its comparatively vigorous growth on dextrose asparagin and potato dextrose agars and its rather poor growth on nutrient agar, Czapek's, and Czapek's agar with glycerine replacing sucrose, at temperatures of 16–19° C., its deep brownish color on the first two agars after 30 days, its larger sporangia, and by its production, in potato dextrose and in Czapek's agar with glycerine replacing sucrose, of a diffusible dark brown pigment. In fact, of the thirteen strains or species which we have in pure culture only two produce such a pigment.

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EXPLANATION OF PLATES

Plate 10

Fig. 1. Planospores of *Actinoplanes philippinensis* No. P 5 killed with fumes of osmic acid and stained with Lee's bacterial flagella stain by W. J. Koch. ×2425. Photograph by Koch.

Fig. 2. *A. philippinensis*. Sporangia on edge of dandelion leaf. Note dots in spores. One sporangium discharging spores. ×700.

Fig. 3. Same material as in Fig. 2. Four sporangia opening, three with spores in chains, one with spores in spirals. ×700.

Fig. 4. Same material. Spores in chains or coils, the masses spreading out. ×700.

Fig. 5. Same material. Several sporangia in various stages of dehiscence, the one on the surface of the leaf with spores distinct on its lower side and densely packed and indistinct on the upper. Hyphae distinct on surface of the leaf. ×700.

PLATE 11

FIG. 1. *Actinoplanes philippinensis*. Thin, crushed section of palisade hyphae showing a single sporangium on the end of most of the threads (on Czapek's agar). ×300.

FIG. 2. Same, but showing a larger and thicker section with many palisade hyphae and many sporangia. ×150.

PLATE 12

FIG. 1. *Micromonospora* (near *chalceae*). Chapel Hill No. 3. Showing large clusters of microspores in darker areas in upper part, one broken off on left. ×400.

FIG. 2. Same but several clusters of microspores spread out by crushing. ×1400.

FIG. 3. *Micromonospora* sp. Chapel Hill No. 4. Microspores in loose clusters. ×700.

FIG. 4. Small cluster of same showing formation of spores. ×1400.

PLATE 10

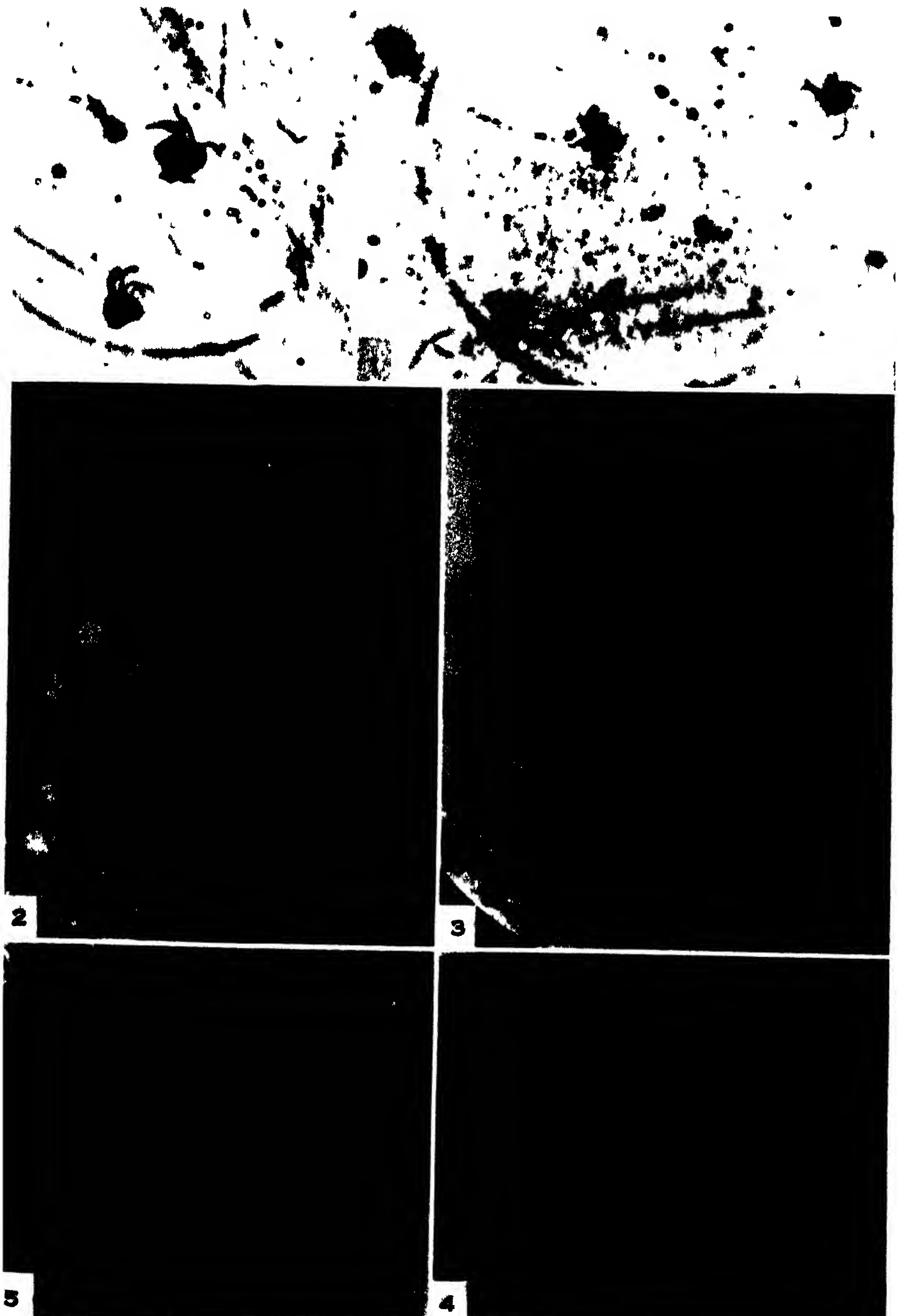


PLATE 11

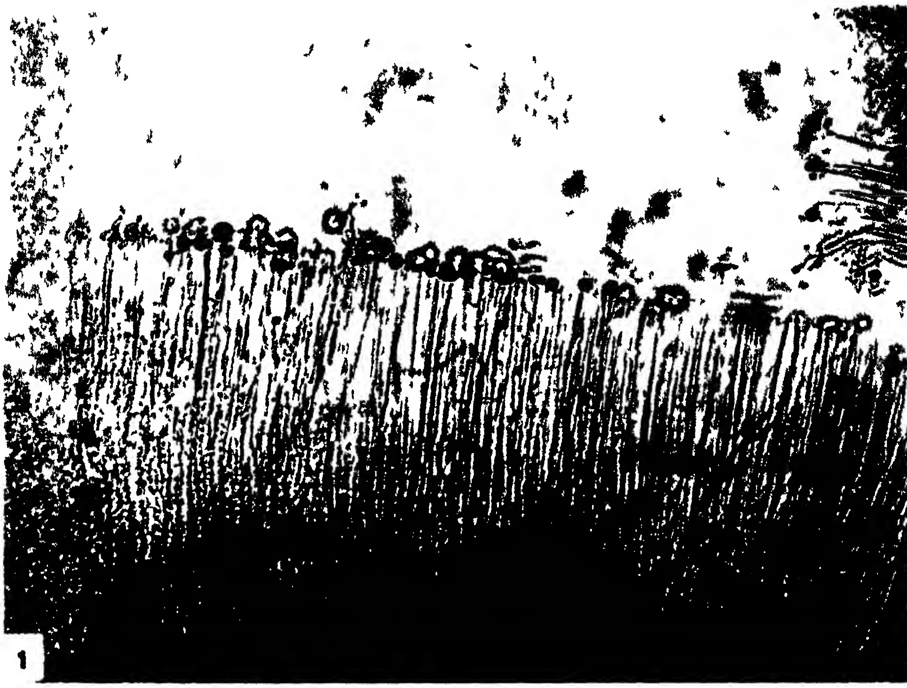
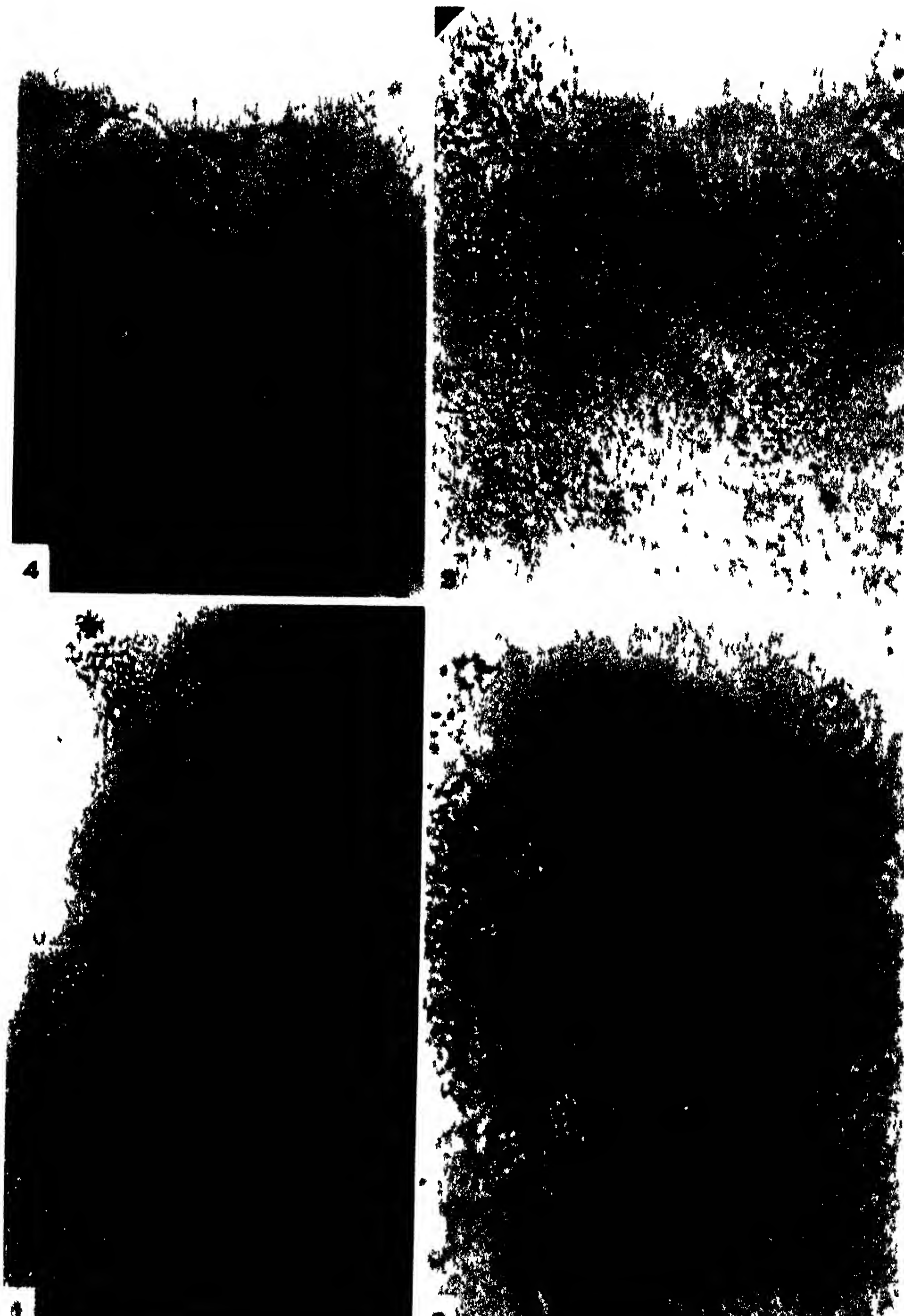


PLATE 12



JOURNAL
OF THE
Elisha Mitchell Scientific Society

Volume 66 December 1950 No. 2

PROCEEDINGS OF THE FORTY-SEVENTH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE

The forty-seventh annual meeting of the North Carolina Academy of Science was held at Catawba College, Salisbury, N. C., on May 5 and 6, 1950.

The Academy convened in a general session at 10:30 a.m. on the first day with President C. F. Korstian presiding. Papers were read at both morning and afternoon sessions. These were followed by the business meeting.

The minutes of the 1949 meeting were approved as published in the Journal of the Elisha Mitchell Scientific Society 65: 167–208. The reports of the various committees were then presented as follows:

Report of the Executive Committee

The Executive Committee met at the home of Dr. M. L. Braun of Catawba College on May 4, 1950, and at luncheon on May 5, 1950. At these meetings the following matters were transacted:

1. The committee authorized the Treasurer to pay all outstanding bills for operating expenses and to submit his financial report as of July 1, 1950, to the auditing committee.
2. The committee voted to become an affiliate of the Southern Association of Science and Industry, Inc.
3. The following were elected to membership in the Academy:

Adams, Elizabeth, Chemistry, Woman's College, U. N C
Beamer, Parker Reynolds, Microbiology and Immunology, Bowman Gray School of Medicine
Berkeley, Edmund, Botany, University of North Carolina
Booth, John Sidney, Chemist, Liggett and Myers Tobacco Company
Brown, Edward B., Botany, Duke University
Bullard, Adelaide Petree, Science, Lumberton High School
Caffey, Michael David, Jr., Psychology, N C State College
Carpenter, Walter Jackson, Mathematics, Western Carolina Teachers College
Chipman, Walter Albert, Biologist, U. S. Fishery Laboratory, Beaufort
Clodfelter, Henrietta, Biology, Catawba College
Cornell, James H , Fish Division, N C. Wildlife Resources Commission
Crowder, Marietta, Biochemistry, Bowman Gray School of Medicine
Davis, David Boyd, Catawba College
Dobrovsky, Todor Manoloff, Entomology, N. C. State College

Donat, Winfield, Education Division, N. C. Wildlife Resources Commission
Douglas, George A., Sociology, Davidson College
Finkner, Morris Dale, Agronomy, N. C. State College
Fogelberg, Sidney Otto, Botany, Carolina Biological Supply Company
Freeman, Claire E., Science, Needham Broughton High School, Raleigh
Funderburg, John B., Jr., Wilmington Junior College
Geary, John Maurice, Entomology, N. C. State College
Goedicke, Thomas Robert, Geology, University of North Carolina
Graham, Fred William, Jr., Botany, Duke University
Green, Harold D., Physiology and Pharmacology, Bowman Gray School of Medicine
Greulach, Victor A., Botany, University of North Carolina
Haynes, Hubert Calvin, Psychology, East Carolina Teachers College
Headinger, Henry A., Carolina Rubber Company, Salisbury
Hornaday, John Albert, Psychology, Woman's College, U. N. C.
Hoyle, Hughes Bayne, Jr., Mathematics and Physics, Queens College
Hughes, Hansel Leigh, Chemistry, Catawba College
Ingram, Roy L., Geology, University of North Carolina
Johnson, Jay W., Junior Curator, N. C. State Museum
Johnson, Willie Clifford, Entomology, N. C. State College
Jones, George D., Entomology, N. C. State College
Jones, Geraldine, Biology, Goldsboro High School
Kaufman, Clemens M., Forestry, N. C. State College
Kelman, Arthur, Plant Pathology, N. C. State College
Lawrence, Benjamin Jones, Jr., Physiology and Pharmacology, Bowman Gray School of Medicine
LeGrand, Harry Elwood, U. S. Geological Survey, Raleigh
Lewis, Anne Louise, Mathematics, Woman's College U. N. C.
Lewis, Jessica H., Physiology, University of North Carolina
McAllister, Claude Huntley, Wilmington Junior College
McComb, Clara Lee, Science, Morganton Senior High School
McFalls, Janice Seeber, Biology, Woman's College, U. N. C.
McLaurin, Angus Winston, Microbiology and Immunology, Bowman Gray School of Medicine
McMillan, John Johnson, Psychology, Duke University
Markgraf, William Frederick, Geology, University of North Carolina
Mitchell, Margaret Capehart, Biochemistry, Bowman Gray School of Medicine
Moreland, Donald Edwin, Botany, N. C. State College
Moss, Beverly C., Clinical Psychology, State Hospital, Goldsboro
Norman, John H., Chemistry, Queens College
Park, Dorothy, Psychology, Meredith College
Phillips, Coy T., Geography, Woman's College, U. N. C.
Powell, Ernest H., Jr., U. S. Fishery Laboratory, Beaufort
Powers, Maurice Cary, Geology, University of North Carolina
Preston, Richard Joseph, Jr., Forestry, N. C. State College
Query, Juanita Noland, Testing Psychologist, Samarcand Manor, Eagle Springs, N. C.
Ritcher, Paul Osborn, Entomology, N. C. State College
Scruggs, Chester A., Science, East Carolina Teachers College
Selfridge, Harry A., Engineering Office, Catawba College
Shannon, Henry Anthony, State Department of Public Instruction
Shugar, Gilbert Lee, Zoology, Duke University
Simpson, Norman Emmett, Botany, Duke University
Smith, Pauline Katherine, Biology, Greensboro College
Stains, Howard James, Zoology, N. C. State College
Stephens, Stanley G., Agronomy, N. C. State College

Tuttle, Dorothy Meyer, Microbiology, Bowman Gray School of Medicine
Tuttle, Robert Lewis, Tropical Medicine, Bowman Gray School of Medicine
Tyndall, Jesse Parker, Science, Atlantic Christian College
Walker, E. M., Campbell Junior College
Watts, George Kenneth, Science, Scotts High School
Welch, Annye Elizabeth, Mathematics, Catawba College
Wiebe, Herman Henry, Botany, Duke University
Wills, Camilla Louise, Science, Atlantic Christian College
Winslow, Edward Leigh, Jr., Institute of Fishery Research, Morehead City
Yancey, Henry, Central High School, Charlotte
Zimmerman, Alice B., Psychology, Woman's College, U. N. C.

4. The following were reinstated as members in the Academy:

Barton, Helen, Mathematics, Woman's College, U N C
Beck, Clifford K., Physics, N. C. State College
Fritz, Robert Lindsay, Mathematics, Lenoir Rhyne College (Emeritus)
Ingraham, Helen Margaret, Biology, Woman's College, U. N. C
Nahikian, Howard M., Mathematics, N. C. State College
Rosen, Nathan, Physics, University of North Carolina
Whyburn, William M., Mathematics, University of North Carolina
Zener, Karl, Psychology, Duke University

5. The Secretary reported the following losses in membership:

1. By resignation. 4
2. By non-payment of dues. 40
3. By death the following
   Fritz John Hansgirg
   William Alexandre Perlzweig
   William Frederick Prouty

6. The Committee accepted the invitation of President A. Hollis Edens to meet at Duke University in 1951.

The above reports of the Executive Committee were adopted by the Academy.

TREASURER'S REPORT

Financial Statement as of July 1, 1950

Receipts	
Bank balance (from July 1, 1949)	$175.64
Gifts	
John Bewley Derieux Memorial Award	50.00
Ornithological Essay Award	20.00
Dues, 1949	4.00
Dues, 1950 (including new members and reinstatements)	790.00
Total	1039.64

Expenditures	
Elisha Mitchell Scientific Society	300.00
Secretarial aid	100.00
Secretarial commission	80.00
High School Awards	75.00
Postage and stamped envelopes	60.72
Stationery, printing and programs (N. C. State Print Shop)	50.65
Transferred to savings account	33.47
Reprints (Waverly Press)	18.20
Expenses to meeting	12.00
Bank charges	7.12
Telephone (long distance calls)	6.75
Ruth M. Addoms (High School Committee)	5.00
Total	748.91
Bank balance	270.73
Cash on hand	20.00
	1039.64

Savings Account

Balance July 1, 1950	100.00

Total Assets

Checking account and cash on hand	290.73
Savings account	100.00
U. S. savings bonds (maturity value)	300.00
Total	690.73

On the first day of July, 1950, we, the undersigned, have examined this account and found it to be correct.

(Signed) H. T. SCOFIELD
H. V. PARK
KEY L. BARKLEY, *Chairman*

REPORT OF THE LIFE MEMBERSHIP COMMITTEE

The committee, consisting of John N. Couch, Maude Williams, and W. L. Porter, recommended that Earl Henry Hall, retired Professor of Botany at the Woman's College of the University of North Carolina, be elected to life membership.

The Academy unanimously elected this scientist to life membership.

The committee further recommended that eligibility for life membership in the Academy be based on the following criteria:

1. Retirement from profession; twenty years of membership in the Academy; and membership in the Academy at the time of his nomination.
2. Notable service to various scientific organizations.
3. Worthy contributions to science in research, teaching or public service.

It is understood that there may be circumstances in which the time requirement may be waived so far as membership in the North Carolina Academy is concerned.

The Academy accepted the report of the committee and approved a motion by

Dr. John N. Couch to dispense with the Life Membership Committee, the duties of which will be performed by the Executive Committee.

REPORT OF THE RESEARCH GRANTS COMMITTEE

The grant of $74.50 for the past year was given to Dr. W. B. Fox and Mr. R. K. Godfrey of N. C. State College. The grant was used for partial defrayment of expenses incurred in a study of the Leguminosae and Compositae of North Carolina.

B. W. WELLS
W. O. PUCKETT
A. D. SHAFTESBURY
O. C. BRADBURY, *Chairman*

REPORT OF THE POTEAT AWARD COMMITTEE

The committee met at noon on Saturday, May 8, 1950, and discussed at length the difficult problem of selecting a meritorious paper presented this year. After due consideration it was decided to grant the award to Dr. C. G. Bookhout of Duke University for his excellent paper, "Development of a marine annelid, *Dasybranchus caducus*, from egg to pre-adult."

E. W. BERRY
A. V. COBLE
D. S. GROSCH
REINARD HARKEMA
H. G. MCCURDY
T. L. QUAY
MARJORIE SWANSON
L. E. ANDERSON, *Chairman*

REPORT OF THE COMMITTEE ON HIGH SCHOOL SCIENCE

I accepted the chairmanship of this committee on condition that: a) it would last for one year only, and that b) the committee could be made up of local people so that meetings could be arranged. This procedure I recommend wholeheartedly, because a committee that can meet is much more efficient than one that has to conduct its business by mail. My committee, consisting of Dr. M. W. Johnson, Dr. H. S. Roberts, Miss Ruby Williams, and Dr. J. H. Highsmith, has worked hard and deserves recognition.

Plans were discussed in the late spring and early summer, because the committee felt it imperative that complete and clear-cut information should be available to high school teachers as early as possible in the fall.

1. The committee decided, with the approval of the President of the Academy and of the donors of prizes, to change the plan of exhibits by dividing them into classes and by offering a cash prize in each class sufficiently large ($20) to attract interest. It was the feeling of the committee that next year's committee might wish to change the classes.
2. In an attempt to make the essay competitions more interesting, the com-

mittee set a definite title for the Forestry Essays (*The Forests of North Carolina and What They Mean to My Community*) and for the Ornithology Essays (*Ways of Attracting Birds to the Home Grounds*), with the idea in mind that next year's committee would set different titles.

In the early fall mimeographed sheets describing both exhibits and essay contests were prepared. Dr. Highsmith helped materially by sending these out to the principals of all white high schools, with the request that they be referred to the science teachers. These sheets were sent out in the fall; October 1 would be the ideal time.

An announcement of the contests was made in the October issue of the magazine of the North Carolina Education Association, and a reminder was printed in the March issue (February would be better). We are indebted to Mrs. Ethel Perkins Edwards for this courtesy.

An effort was made to stimulate interest among science teachers by asking someone to announce the competitions at each of the district meetings in the fall. The committee is indebted to several members of the Academy for this service.

Essays were due on March 1. Seven Ornithology essays and fourteen Forestry essays were submitted and they were read by committees appointed by the President of the Academy.

Exhibits were to be listed with the chairman of the committee by April 15. At that time, it became necessary for the chairman to relinquish the work; and the committee graciously agreed to carry on under the chairmanship of Dr. H. S. Roberts. To my hard-working committee and to all other members of the Academy who have helped the committee, I offer my heartfelt thanks.

RUTH M. ADDOMS

Announcement of the winners of the various high school student contests was made at the evening meeting by Dr. H. S. Roberts as follows:

FORESTRY ESSAY CONTEST

(*Sponsored by N. C. Forestry Association*)

First Prize: Philip Leinback, R. J. Reynolds High School, Winston-Salem
Second Prize: Mildred Jenkins, Scotts High School, Scotts
Third Prize: Edwin Stockton II, R. J. Reynolds High School, Winston-Salem

ORNITHOLOGY ESSAY CONTEST

First Prize: Dan McIntyre, Goldsboro High School, Goldsboro
Second Prize: Billie Jean Everhart, Boyden High School, Salisbury
Third Prize: Ralph Dwiggins, Gray High School, Winston-Salem

EXHIBITS CONTESTS

Category A: Living Plants or Animals (Sponsored by Carolina Biological Supply Co.)

First Prize: Room 305, Central High School, Charlotte
"Backyard Biology"
Honorable Mention: Tony Anthony and Amos Johnston, Gastonia High School
"Live Animals"
Category B: Preserved Plants or Animals (Sponsored by Carolina Biological Supply Co.)
First Prize: Mary Poole, Central High School, Charlotte
"Insect Collection"
Honorable Mention: Sarah Luckadoo, Morganton High School
"Pressed Plants"
Honorable Mention: Kenneth Rudolph and Bevan Barrington, Boyden High School, Salisbury.
"Skeletal Preparations"
Category C: Models
First Prize: Roger Little, Central High School, Charlotte
"Model of Still"
Honorable Mention: Hubert Jack Heard and Wilson Otto Woods, Central High School, Charlotte
"Ceramics"
Honorable Mention: Mary Cole, New Hanover High School, Wilmington
"Wood Burnings of Animals"
Honorable Mention: Charles Snipes, New Hanover High School, Wilmington
"Grafting Demonstration"
Category D: Unrestricted Original Exhibits
First Prize: Sara Jo Hensley, Morganton Senior High School
"Dissectible Human Torso"
Especial Mention: Jack Baugh, Central High School, Charlotte
"Modified Automobile"
Honorable Mention: Mary Nisbet, Central High School, Charlotte
"Plastics"
Honorable Mention: Alex Efird, New Hanover High School, Wilmington
"Charts of the Animal Kingdom"
Honorable Mention: J. K. Patterson, Boyden High School, Salisbury
"Nature Photography"

REPORT OF THE CONSERVATION COMMITTEE

The committee has attempted to focus attention on four problems which should concern most of the members of the Academy. Although there are numerous other problems in need of attention, we felt that it would be more practical to select several specific ones on which we might take some action.

Therefore, we are not presenting these with the thought that they be merely recorded and placed in the minutes of this meeting. We feel that the Academy should take steps to activate and implement the following proposals.

The four problems we have selected for consideration are:

1. Need for legislative action to control the sale of Venus fly traps.

2. Need for legislative action to pass upon and control the introduction of exotic game species of animals.
3. The need for adequate appropriations to establish statewide forest fire control and to increase the technical forestry advice and assistance to the owners of small tracts of forest land.
4. Finally, the need for legislation to establish statewide regulatory control for the correction of stream pollution in the state.

We propose various degrees of action on these four proposals. In the case of the Venus fly trap and exotic game species, we feel the Academy needs to initiate the action and seek the cooperation of other groups. In the problems of forest fire control and stream pollution control, other groups have already and will continue to press for funds and legislative action and we need to assist these groups in every way possible.

Therefore, we submit the following four brief reports with resolutions attached, for your consideration and action.

I. Venus Fly Trap

WHEREAS:

The Venus Fly Trap grows nowhere else but in a restricted number of counties in the Coastal Plain of North and South Carolina. Its curious mechanism, which causes the leaf-blade to snap shut upon physical stimulus, permits the trapping of insects which are subsequently digested by enzymes which it secretes. These peculiar characteristics caused Darwin to describe the plant as the most wonderful in the world. The plant is probably known by more botanists and naturalists throughout the world than any other, and it has been the subject of study by many of them.

Fortunately, it is plentiful where it grows, and the occasional removal of a few plants has not seriously reduced its range or numbers. Now, however, a few people have started digging it for commercial purposes. Truckloads have been hauled to various cities around the State and the plants sold there on the street and in stores. Such activity, if it continues, can only mean the extermination of an unique plant—far more unusual than many others which have been protected elsewhere (orchids, for example). A related species from California was, at one time, sold in dime stores all over the country and as a result, has been almost eliminated.

It is a disgrace that a biological curiosity of this sort should be sold for the profit of a few people and at the risk of its extermination. The sale of the plant should be stopped, since it violates the spirit of conservation and there is a definite possibility that the plant may be exterminated.

Some evidence has been collected as to the extent of the sale of this plant. One person is devoting full-time to its sale and two others part-time. Thousands and thousands of plants have been sold in North Carolina cities and towns this year and thousands more shipped to New York and other places in response to orders resulting from advertisements in National and Metropolitan papers and magazines.

The presence of the trucks in our cities and towns and the sales to our school children represents the worst kind of conservation education and needs to be stopped immediately.

THEREFORE, BE IT RESOLVED:

(a) That the legislative committee of the Academy seek the cooperation of the responsible agencies in the State, principally the Department of Conservation and Development, and draft a bill for presentation at the next session of the Legislature which would prohibit its sale, provide for responsibility in protecting the plants, and impose a suitable fine for infractions of the regulations.
(b) That the Academy publicize the problem and seek the assistance of other interested groups in supporting the bill, particularly the Garden Clubs and Women's Clubs.

II. Introduction of Birds and Mammals in North Carolina

WHEREAS:

The indiscriminate introduction of wild birds and mammals from outside the State of North Carolina for release in this State constitutes a threat to our native species with which competition is bound to occur.

The successful introduction of birds and mammals, especially exotics, frequently results in serious losses to agricultural interests and often requires vast expenditures of public funds to eradicate or even control them. The armadillo recently established in Florida and the fox squirrel in California are costing those States thousands of dollars annually. The "male" Kansas jack rabbits liberated for coursing in the Sandhills area of North Carolina are still causing considerable damage to peach and apple trees fifteen years after their introduction.

Of the forty human diseases required by the North Carolina State Board of Health to be reported, birds and mammals are the only sources of seven and are an important source for two more.

Wild birds and mammals frequently serve as the reservoir for the dissemination of disease organisms and parasites of great economic importance to domestic animals.

The wild birds and mammals already in this State have undergone thousands of generations of rigorous selection incident to survival in the wild and are best adapted to our environmental conditions.

Through selection, specific genetic situations have been established for the game population of this State and the introduction of other types would promote hybridization. It is well established that crossing of different strains, races, subspecies (or even species, as is possible in certain cases), often produces abnormal size and vigor *in the first generation* hybrids followed by a corresponding tendency toward debility or defect *in succeeding generations* (if abnormality is not so extreme as to produce sterility).

There is sufficient wild breeding stock of our native species present within the boundaries of this State for transplanting and release in deficient North Carolina areas.

The introduction of wild birds and mammals into North Carolina affects the health, economy, and welfare of all the people of this State and no single agency now exists which has the personnel or facilities to handle adequately this highly technical problem and to protect the interests of all groups for the benefit and protection of the whole.

THEREFORE, BE IT RESOLVED:

(a) That the legislative committee of the North Carolina Academy of Science seek the cooperation of the North Carolina Department of Agriculture and the North Carolina Wildlife Resources Commission and the Wildlife Federation and other interested groups, to draft the necessary legislation to create a Board composed of a representative from each of the following agencies:

North Carolina Department of Agriculture
Office of State Veterinarian
State Board of Health
Wildlife Resources Commission
North Carolina Agricultural Experiment Station
A recognized ecologist from an institution of higher learning in this State.

(b) The above mentioned legislation would provide that no introductions of exotic or native wild birds or mammals would be made in this State without prior unanimous approval by this Board.

(c) That enforcement of the rulings by the Board would be through those agencies now charged with such regulatory responsibilities.

III. Forest Fire Control and Forestry Assistance

WHEREAS:

(a) Some fifty-nine per cent of our State's land area is now in forest and approximately that same percentage of our area should always remain in tree growth.

(b) What we do with our woodland will in a large measure determine our success in controlling floods, in supplying the raw materials for industry and commerce, and in maintaining the ground water level essential to profitable farming.

(c) The average forest acre in North Carolina pays annually an estimated twelve cents in county taxes, thirty cents in various State taxés, and probably at least thirty cents in various Federal taxes.

(d) Increased attention must be given to the protection of our forest resources against wild fire and against unwise forest management practices.

(e) Two-thirds of the forest land of North Carolina is held in small ownerships and wise management and utilization of our timber resources cannot be established without active cooperation of the owners of these lands.

THEREFORE, BE IT RESOLVED:

That the North Carolina Academy of Science assist in every way possible the efforts of the North Carolina Division of Forestry, the North Carolina Forestry Extension Division, and the North Carolina Forestry Association and Council, and other interested groups in:

(a) Establishing through appropriation of adequate funds a statewide forest fire control program on equal terms with neighboring states.
(b) Making available tree seedlings to reforest our estimated one million acres of idle non-agricultural land.
(c) Increasing the technical advice on forestry and assistance needed by the owners of small tracts of forest land so as to make the fullest use of the State's economy, since good forest management is absolutely essential to successful agriculture and industry in our State.

IV. Stream Sanitation

WHEREAS:

There is at present no Board, Commission, or Committee that has authority to prevent any town, city, or industry from putting raw sewage and industrial waste into the streams of the State, unless they directly affect a public water supply.

The State Stream Sanitation and Conservation Committee, set up by an Act of the 1945 General Assembly, has studied numerous corrective acts as passed by other states and presented to the 1949 General Assembly for regulatory authority a recommended bill that was felt by the Committee to be the most workable one.

The 1949 General Assembly did not see fit to pass this recommended bill, and the growth of North Carolina is rapidly increasing in both industry and population, adding a greater load of sewage to the already heavily burdened streams.

The State of North Carolina is suffering a great loss in revenue directly to the State and also to the individuals of the State due to the present conditions of some of the waters. With more domestic and industrial waste added each year, it is realized that the longer the delay for such regulatory authority the longer it will take to bring the streams and waters of the State to a useable condition.

Fish and wildlife are being destroyed by pollution and thus destroying recreation and in some cases a livelihood for the citizens of the State.

THEREFORE, BE IT RESOLVED:

By the North Carolina Academy of Science that the North Carolina General Assembly be urged to leave no stone unturned in seeing that the State Stream Sanitation and Conservation Committee be given regulatory authority for the correction of stream pollution by the passage of a bill to that effect in the 1951 session, and that the Academy actively assist all other interested groups in the passage of this much-needed legislation.

F. S. BARKALOW, JR.
H. J. OOSTING
W. D. MILLER
W. A. RILEY
J. L. STUCKEY
R. L. WEAVER, *Chairman*

The above report was unanimously endorsed by the Academy.

REPORT OF REPRESENTATIVE TO ACADEMY CONFERENCE

The Conference of State Academies of Science of the AAAS met at the Hotel New Yorker on Friday, December 30, 1949. It was called to order by the Chairman, Dr. Frank E. E. Germann. There were 33 present, of whom 14 were official delegates to the Conference.

The first speaker on the program was Dr. Howard A. Meyerhoff, Administrative Secretary of the AAAS. His subject was "Congress and the National Science Foundation." He told of the present status of the National Science Foundation and reported that its prospects of adoption by the Congress are good. This prediction has recently been realized.

The second paper on the program was presented by Dr. W. A. Macfarlane, Director of the United Kingdom Scientific Mission in North America. His subject was "The Organization of Government Science in the United Kingdom." He demonstrated that there has been a genuine endeavor by all governments in Great Britain *not* to interfere with scientists and their ways of working, while trying to help in the development of science.

Dr. Watson Davis of Science Service spoke on "A National Program for the Science Talent Search." This paper presented the accomplishments and prospects of the Science Talent Search. It was pointed out that the opportunity for home work is frequently the stimulus to becoming a scientist, that it is important to realize early in life what is the scientific method, and that science clubs lead to science fairs or congresses.

Dr. P. N. Powers of the Atomic Energy Commission presented his paper on "The Changing Manpower Picture". This paper has since been published in the March 1950 issue of *The Scientific Monthly*. It was shown very lucidly that the "shortage-of-scientists" problem, as we have known it during the past few years, is about over. There is, however, the new problem of keeping supply and demand in balance.

There was then a paper by Mrs. Madeline Fink Coutant on "The Science Congress Movement in New York State." Mrs. Coutant is on the staff of Hartwick College and is Director of the Oneonta Science Congress. High School members of that congress presented demonstrations of their work and a colored motion picture of the last congress was shown. The members of the Conference were made very conscious of the challenging opportunity envisioned by this program.

The speaker at the Academy Conference dinner was Dr. William G. Pollard, Executive Director of the Oak Ridge Institute of Nuclear Studies. He spoke on "The Oak Ridge Institute of Nuclear Studies and the Atomic Energy Programs in the Associated Universities."

REINARD HARKEMA

REPORT OF THE RESOLUTIONS COMMITTEE

Be it resolved that the North Carolina Academy of Science express to President Alvin R. Keppel, the administrative officers, the faculty, and student body of Catawba College its deep appreciation for the gracious hospitality and the many courtesies extended it at this meeting; be it resolved further that especial thanks

be extended to Professor Milton L. Braun and to the local Committee on Arrangements whose attention to details has contributed so much to this the forty-seventh annual meeting of the Academy; also, be it resolved that this report be entered into the minutes of this meeting and a copy be sent to President Alvin R. Keppel and to Professor Milton L. Braun.

EDWARD T. BROWNE

The above report was unanimously approved by the Academy.

The following memorial reports were presented at the meeting:

FRITZ JOHN HANSGIRG

Dr. Fritz J. Hansgirg died suddenly on July 23, 1949, at the age of 58. He was living in New York where he served as chief engineer for the Electro-Metal Corporation and the Bach Corporation, and consultant for the Standard Oil Company of New Jersey.

Dr. Hansgirg was born in Graz, Austria. It was here that he received his formal education, which culminated with a doctor's degree from the University of Graz. Starting as an organic chemist specializing in dyes, Dr. Hansgirg moved into the domain of oils, simultaneously into the study of electrolytic and electrothermic processes, and into the heart of metallurgy where he finally became an authority in magnesium. At the same time he became interested in catalytic reactions, a very complex field, and emerged with a new catalytic process for the production of hydrogen. Through his interest in electro-chemistry he studied the electrolytic deposition of oxides. In the midst of his work on the production of magnesium he became interested in the chemistry of isotopes and in his spare time devised a method for the production of heavy water.

The knowledge of so many fields—organic chemistry, metallurgy, electrochemistry, physics—is rather unusual. One can only admire these outstanding achievements; very few scientists have the privilege of venturing outside their own field. It has to be noted also that Dr. Hansgirg was a very fine musician, had an extraordinary knowledge of painting, and an extremely wide knowledge of literature.

His life work necessitated many business trips throughout the world where he worked and studied, built plants, produced materials, but there were many other trips when he was not an engineer or scientist, but just a man avid to know different people, customs and cultures.

In September, 1942, he joined the faculty of Black Mountain College where he erected a research laboratory, and combining his teaching with personal research he developed a process for reducing magnesium from Western Carolina Olivine. In addition he prepared the manuscript for a book on "Energy and Matter."

His students were fascinated by his immense knowledge and unlimited enthusiasm with which he colored his lectures. It was for everyone of them an experience they will never forget. He imbued them with the intellectual curiosity so exceedingly important for every student of science. For four years Black

Mountain College profited by the presence of such an extraordinary man. His human quality, refinement, and knowledge were rare.

His premature death will be felt in many areas of human activity. The scientific world loses one of the foremost experts in the metallurgy of magnesium; the industrial world loses an outstanding administrator; his friends and acquaintances feel the loss of a great teacher and a man whose intellectual and artistic refinement was a rare example of what civilization can achieve.

NATASHA GOLDOWSKI

The above memorial was approved by a rising vote.

WILLIAM ALEXANDRE PERLZWEIG

Dr. Perlzweig, first Professor of Biochemistry in the Duke Medical School, was born in Ostrog, Russia, on April 23, 1891. When 15 years old he came to this country and completed his education. He won the Bachelor of Science degree in 1913 and the Ph.D. degree in 1916 from Columbia University. He then spent a year at the Rockefeller Institute for Medical Research in New York. From 1917 to 1919 he was in the U. S. Army, commissioned a first lieutenant in the Sanitary Corps. Following his discharge, he lived in Baltimore, Maryland, working first at the Hygienic Laboratory of the Public Health Service and then as chief chemist to the medical department of the Johns Hopkins Hospital.

In 1930 he was appointed by Dr. Davison to organize the Department of Biochemistry in the new medical school at Duke University. Under his guidance the department has grown in size and in quality. Dr. Perlzweig's interests were catholic; he was ever a champion of close teamwork between the laboratory and clinic. For the past 20 years of his life, he carried forward the growth of his department and has trained many disciples whose work in various parts of the country testify his ability as a teacher and a leader. His death on December 10, 1949, after several months of illness is a great loss not only to Duke University but to North Carolina's scientific structure and to the North Carolina Academy of Science.

During his lifetime Dr. Perlzweig was active in research as well as in teaching and administration. His many publications include studies of the pneumococcal antigen, metabolic diseases, mineral metabolism, enzymes, and particularly metabolism of the members of the vitamin B complex. He counted among his colleagues and co-authors other eminent scientists such as Leonor Michaelis, Chester Keefer, Tinsley Harrison, E. S. Gusman-Barron, and Sergius Morgulis.

Dr. Perlzweig was a very lovable man; his geniality endeared him to many friends throughout this country and abroad. His colleagues at Duke Medical School will miss him not only as an able, encouraging and helpful associate but as an affectionate friend.

MACDONALD DICK

The above memorial was approved by a rising vote.

WILLIAM FREDERICK PROUTY

William Frederick Prouty, Professor of Geology in the University of North Carolina since 1919 and Head of the Department of Geology and Geography

since 1933, died on June 27, 1949. His forebears were of old New England stock and his early training and education were in that tradition. He possessed a lean and hardy frame which enabled him to carry on geological field work with a vigor and endurance envied by far younger men. As a teacher and department head, he maintained a friendly atmosphere for students and made them feel at ease and at home in the department. He was not too strict about locking doors, but rather made laboratories and equipment available to qualified students and encouraged them to work beyond scheduled hours. His students soon came to respect his interest and confidence in them and losses of materials and specimens from the department were at a minimum.

He was born in Putney, Vermont, August 15, 1879. His college education was obtained at Syracuse University, where he received the Bachelor of Science degree in 1903 and the Master of Science degree in 1904, and at Johns Hopkins University where he received the Doctor of Philosophy degree in 1906.

Prior to coming to the University of North Carolina, he had served as Chief Assistant on the Alabama Geological Survey and as Associate Professor and Professor of Geology in the University of Alabama. In 1919, he joined the faculty of the University of North Carolina as Professor of Stratigraphic Geology. In 1924, he became Professor of Structural and Economic Geology and in 1933 he succeeded Professor Collier Cobb as Head of the Department of Geology and Geography.

During the thirty years he taught at the University of North Carolina, in addition to his teaching duties, he found time to engage in geological research and consultation. He served as Geologist on the North Carolina Geological and Economic Survey from 1920 to 1924, as Paleontologist on the West Virginia Geological Survey from 1922 to 1925 and as consultant with the Tennessee Valley Authority from 1938 until his death.

His first important research was on the Silurian of Maryland, which served as his doctoral dissertation. At intervals thereafter, he wrote papers on the Silurian of the Southern Appalachians, the last of which was published in 1941. He was interested in the Triassic formations of North Carolina and the structure of folded mountains and published papers on these subjects. His chief interest, however, was in Economic Geology and it was in this field that he did his major research. As an Economic Geologist he did outstanding work on (1) the bedded iron ores of Alabama, (2) the marbles of Alabama, Tennessee and Maryland, (3) the Coosa Coal Field of Alabama and (4) the graphite deposits of Alabama. It should also be noted that he shared authorship in three folios of the Geological Atlas of the United States.

In his latter years he became greatly interested in the origin of the "Carolina Bays." He was a believer in the meteoric theory of their origin, and his long and careful investigations gave it strong support. Most of his work on the Carolina Bays remains unpublished. At the time of his death, he had just completed the first draft of an extensive paper, which, when published, will no doubt have an important influence upon geological opinion concerning the origin of the Bays.

On June 9, 1909, he married Lucile W. Thorington of Montgomery, Alabama, daughter of a former Dean of the Law School of the University of Alabama, who

survives him together with their three sons: Frederick Morgan Prouty, William Walker Prouty, and Chilton Eaton Prouty.

Soon after coming to the University of North Carolina, he became a member of the North Carolina Academy of Science and regularly took an active part in its programs. He served as President of the Academy in 1931. The Academy has lost a valuable colleague and friend and the family a devoted husband and father.

JASPER L. STUCKEY
WILLIAM A. WHITE.

The above memorial was approved by a rising vote.

REPORT OF THE NOMINATING COMMITTEE

The committee, consisting of O. C. Bradbury, Chairman, M. L. Braun and F. G. Hall, submitted the following nominations:

President: A. S. Pearse, Duke University

Vice-President: E. L. Mackie, University of North Carolina

Member of the Executive Committee: E. C. Cocke, Wake Forest College

Members of the Research Grants Committee: Ruth M. Addoms, Duke University, and G. R. MacCarthy, University of North Carolina

There being no nominations from the floor, the Secretary was asked to cast the ballot and declare the nominees elected. This concluded the business and the meeting was adjourned.

At 6:00 p.m. the members enjoyed a complimentary barbecue supper given by Catawba College. At 8:00 p.m. the evening session was held in the Auditorium of the Main Building, with Vice-President W. O. Puckett presiding. The winners of the various High School Student Contests were announced by Dr. H. S. Roberts. Dr. Puckett presented President Alvin R. Keppel of Catawba College who welcomed the Academy to the Campus. President C. F. Korstian then presented his informative and interesting address, "Growing Successive Crops of Pine in North Carolina." The members then adjourned to the Student Union where they were entertained by the wives of the Catawba College Faculty.

The sectional meetings were well attended. The following officers were elected for the respective sections:

Biochemistry and Physiology: Chairman, K. M. Wilbur and Susan Gower Smith; Secretary, Marjorie Swanson.

Botany: Chairman, Lewis E. Anderson; Secretary, W. B. Fox.

Geology: Chairman, R. L. Ingram; Secretary, E. W. Berry.

Mathematics: Chairman, D. C. Dearborn; Secretary, H. B Hoyle, Jr.

Psychology: Chairman, Key L. Barkley; Secretary, Marion Stanland.

Wildlife: Chairman, Win Donat; Secretary, W. L. Hamnett.

Zoology: Chairman, H. K. Townes; Secretary, D. S. Grosch.

The following constitute the personnel of the standing committees:

Executive: A. S. Pearse, E. L. Mackie, Reinard Harkema, A. F. Thiel, C. H. Bostian, E. C. Cocke.

Research Grants: W. O. Puckett, A. D. Shaftesbury, G. R. MacCarthy, Ruth M. Addoms.

Dr. A. S. Pearse, President of the Academy for 1951, announced the appointment of the following committees:

Auditing: Key L. Barkley, H. V. Park, H. T. Scofield.

Conservation: R. L. Weaver, B. W. Wells, F. S. Barkalow, W. D. Miller, Coy T. Phillips.

High School: Inez Coldwell, Charlotte Dawley, Jane C. Frost, Hollis Rogers, H. A. Shannon.

Legislative: Harry T. Davis, R. L. Weaver, J. L. Stuckey.

Nominating: J. W. Lasley, Jr., F. G. Hall, C. F. Korstian.

Poteat Award: D. S. Grosch, E. W. Berry, W. B Fox, W. L. Hamnett, Reinard Harkema, H. B. Hoyle, Jr., Marion Stanland, Marjorie Swanson.

Resolutions: O. C. Bradbury.

Representative on A. A. A. S. Council: D. P. Costello.

Representative to Academy Conference: D. P. Costello.

Constitution: H. L. Blomquist, H. R. Totten, Reinard Harkema.

John Bewley Derieux Memorial Award: Anna Joyce Reardon, O. J. Thies, Jr., Nathan Rosen.

Approximately 350 members and guests registered during the meetings.

The following papers were presented during the meetings. Those marked with an x are abstracted in these proceedings:

GENERAL SESSIONS

Addresses of Welcome. President A. R. KEPPEL and Dean D. C. DEARBORN, Catawba College.

Presidential Address: Growing successive crops of pine in North Carolina. C. F. KORSTIAN, Duke University.

x*The fundamental action potentials developed in the lobes of Venus' fly-trap due to a stimulus.* OTTO STUHLMAN, JR., U. N. C.

The Cape Fear region in late Pleistocene. B. W. WELLS, N. C. State.

x*Translocation of radioactive phosphorus in loblolly pine* (Pinus taeda *L.*) D. E. MORELAND, N. C. State.

x*A Study of the permeability of certain epidermal membranes to gaseous carbon dioxide.* W. M. DUGGER, N. C. State.

Aeration and water absorption. P. J. KRAMER, Duke (Read by title only).

Inhibition of bacterial cell division by anticoagulants. JOHN R. WARREN and FRED W. GRAHAM, Duke.

The seasonal succession of orthopteran stridulation near Raleigh. B. B. FULTON, N. C. State.

Screwworm outbreaks and its activity. G. D. JONES, N. C. State.

The effect of pentathal sodium on the ascorbic acid level of the whole blood of man. A. E. A. HUDSON, N. C. State (Read by title only).

Transfusion via the bone marrow route. HENRY TURKEL, Detroit, Mich. (Read by title only).

The physics of color television. H. A. SELFRIDGE, Catawba.

BIOCHEMISTRY AND PHYSIOLOGY SECTION

Evaluation of peripheral circulation in man by means of constant temperature studies and use of radio-sodium. CREED MCFALL, H. D. GREEN, RICHARD POLLITZER, and MICHAEL MOORE, Bowman Gray.

Experimental studies on leptospirosis. P. R. BEAMER, Bowman Gray.

Constancy of responses to intra-arterial injection of mecholyl in the isolated, blood-perfused extremity: Perfusion with a pump-oxygenator system. B. J. LAWRENCE, JR., A. B. DENISON, JR., J. M. LITTLE, and H. D. GREEN, Bowman Gray.

x*Tissue activators of a serum enzyme.* JESSICA H. LEWIS and J. H. FERGUSON, U.N.C.

Decarboxylation of cysteic acid. J. C. ANDREWS and J. F. R. KUCK, U.N.C.

Enzymatic disappearance of formaldehyde in the presence of pyruvate. PEGGY MITCHELL and CAMILLO ARTOM, Bowman Gray.

Studies on dimethyl ethanolamine as a possible intermediate in choline metabolism. MARIETTA CROWDER and CAMILLO ARTOM, Bowman Gray.

Biochemical studies on several strains of Histoplasma capsulatum. A. W. MCLAURIN and DOROTHY TUTTLE, Bowman Gray.

The nicotine content of breast milk from cigarette smokers. W. A. WOLFF and J. F. DONNELLY, Bowman Gray.

The action of various metallic ions on the phosphatases of liver. MARJORIE SWANSON, Bowman Gray.

BOTANY SECTION

Some observations on plant succession in thinned pine stands of the Piedmont. S. G. BOYCE, N. C. State.

Effects of soil sterilization on survival of grass seedlings. FELTON NEASE, Duke.

An enumeration of noteworthy distributional records for North Carolina Compositae R. K. GODFREY, N. C. State.

Notes on the distribution of North Carolina plants. W. B. FOX and R. K. GODFREY, N. C. State.

Notes on Isoetes in North Carolina. A. E. RADFORD, U. N. C.

The rushes of North Carolina. WADE BATSON, Duke.

Technique of preserving and mounting blue-green algae (Demonstration). E. C. COCKE, Wake Forest.

Additions to the State list of fresh-water algae. L. A. WHITFORD, N. C. State.

Gemmae in Lophocolea heterophylla *(Schrad.) Dum.* H. L. BLOMQUIST, Duke.

A new species of Mnium from North Carolina. LEWIS E. ANDERSON, Duke.

The effect of mineral oil upon lateral buds of tobacco. D. B. ANDERSON, N. C. State.

x*Storage of isolates of* Pseudomonas solanacearum *under mineral oil in relation to virulence.* ARTHUR KELMAN and J. H. JENSEN, N. C. State.

The conditions which determine the formation of sporangia in some organisms related to Streptomyces. JOHN N. COUCH, U. N. C.

GEOLOGY SECTION

Roundness changes in Cape Fear River sand. R. L. INGRAM and M. C. POWERS, U. N. C.

Geological investigation aids mineral production. J. L. STUCKEY, N. C. State.

Lightweight aggregate and glass fiber from Florida phosphates. POOLE MAYNARD, Atlantic Coast Line Railroad.

Mineral changes in the weathering of Triassic Dikes near Chapel Hill, N. C. W. F. MARKGRAF, M. C. POWERS and J. R. RECKNAGAL, U. N. C.

x*A Cretaceous log jam.* E. W. BERRY, Duke (Read by title only).

x*A megascopic roundness scale.* M. C. POWERS, U. N. C.

The Capture Cycle. W. A. WHITE, U. N. C.

x*Some geological observations in Caldwell and Watauga Counties, western North Carolina.* T. R. GOEDICKE, U. N. C.

x*A discussion of red granites.* GLENN E. MCKINLEY, N. C. State.

Geological control of drainage in the slate belt of Stanley and Cabarrus Counties, North Carolina. F. O. BOWMAN, JR., U. N. C.

MATHEMATICS SECTION

On the fundamental theorem of conformal mapping. W. J. CARPENTER, Western Carolina Teachers College.

Some whys and hows of teaching mathematics. WHITFIELD COBB, Guilford.

Solving verbal problems in algebra. R. L. FRITZ, SR., Lenoir-Rhyne.

A method of finding irrational roots of algebraic equations. H. B. HOYLE, Queens.

Some remarks on Stokes' Theorem. H. M. NAHIKIAN, N. C. State.

The number of genera of binary quadratic forms with even discriminant. ANNYE ELIZABETH WELCH, Catawba.

The circular and hyperbolic functions. W. M. WHYBURN, U. N. C.

PSYCHOLOGY SECTION

(N. C. Psychological Association)

Presidential Address: Some tentative suggestions toward improvement of methodology in learning research. KARL ZENER, DUKE.

WILDLIFE SECTION

An economic survey of North Carolina's wildlife resources. H. J. STAINS, N. C. State.

Observations on the seasonal and geographic distribution of the squirrel warble (Cuterebra *sp.*) *in North Carolina.* RAY ALLISON, N. C. State.

Some natural history museum techniques for school use. JAY W. JOHNSON, N. C. State Museum.

Age, sex and weight ratios of mourning doves in North Carolina. T. L. QUAY, N. C. State.

Mortality in bass and sunfish subsequent to capture and release. J. H. CORNELL and W. E. ELLIS, Wildlife Resources Commission.

Deer disease in North Carolina. B. F. COX, N. C. State.

ZOOLOGY SECTION

x*Development of a marine annelid,* Dasybranchus caducus, *from egg to pre-adult.* C. G. BOOKHOUT, Duke.

Notes on immature stages of Lucaninae (Coleoptera: Lucanidae). TOM DAGGY, Davidson.

Some postembryonic changes in the digestive tract of the worker honeybee. T. M. DOBROVSKY, N. C. State.

x*Cytological aspects of the spinning glands of the parasitic wasp, Habrobracon, from Feulgen preparations.* D. S. GROSCH, N. C. State.

x*A preliminary study of lens regeneration in* Pseudacris nigrita feriarum. E. C. HORN, Duke.

x*The inheritance of ectrodactylism. Part II. Statistical tests of alternative hypotheses of its inheritance.* C. D. HOWELL, Catawba.

Contributions to the life history and morphology of the trematode, Gynaecotylea adunca *(Linton, 1905).* WANDA SANBORN HUNTER, Duke.

x*Phosphorus exchange in the shell of the oyster.* LOUISE H. JODREY and K. M. WILBUR, Duke.

x*Experimental production of pulmonary artery anomalies in chick embryos.* M. W. JOHNSON and L. J. MANHOFF, JR., Duke.

The fauna of the reefs off the Carolina coast. A. S. PEARSE, Duke.

N. C. SECTION OF AMERICAN CHEMICAL SOCIETY

A novel application of the Diels-Alder reaction. PELHAM WILDER, Duke.

Preparation of some fluoroisoquinolines. C. E. TEAGUE, JR., and ARTHUR ROE, U. N. C.

Reactions in the m-terphenyl series. C. K. BRADSHER and I. SWERLICK, Duke.

The activity coefficients of sulfuric acid in aqueous 2-propanol solutions at 25°. H. D. CROCKFORD and J. E. LAND, U. N. C.

Heat capacity of $K_3Fe(CN)_6$ *and* $K_3Co(CN)_6$ *from 15–300°K.* CHARLES MORROW, U.N.C.

The physical properties of some fluorine compounds. MARCUS HOBBS and LEONARD CHERRY, Duke.

The determination of the dissociation constants of the monofluoroquinolines from spectrophotometric measurements. W. K. MILLER and S. B. KNIGHT, U. N. C.

Synthesis of organic compounds containing Iodine 131. R. L. HAYES and ARTHUR ROE, U. N. C.

Attempts to detect an isotope effect of Carbon 14. MAX HELLMAN and ARTHUR ROE, U. N. C.

Metallic cation effects in reactions of bases with organic compounds. F. W. SWAMER and C. R. HAUSER, Duke.

The Lactobacillus Bulgaricus factor, an unidentified bacterial vitamin. W. L. WILLIAMS, N. C. State.

Microbial studies on the L. Bulgaricus factor and the relationship of the factor to known vitamins. R. A. MCRORIE and W. L. WILLIAMS, N. C. State.

Concentration of the L. Bulgaricus factor and its chemical nature. P. M. MASLEY and W. L. WILLIAMS, N. C. State.

Abstracts:

The Fundamental Action Potentials Developed in the Lobes of Venus' Fly-trap Due to a Stimulus. OTTO STUHLMAN, JR.

The Venus' fly-trap, *Dionaea muscipula,* is included in a small group of plants designated by botanists as carnivorous because of its reputed ability to digest insects and small bits of living matter caught in the trap structure from which the plant takes its popular name.

J. Burdon-Sanderson as early as 1873 discovered "The Electromotive Properties of the Leaf of Dionaea in the Excited and Unexcited States." With the aid of a capillary electrometer he was able to record, as a result of stimulating the inner surface of a lobe, a short-lived positive electrical increase followed by a larger negative rise and fall in potential when the electrodes were placed symmetrically on the two outer surfaces of the trap. The electrical transient was found by him to last about one second and its propagation speed, at 38°C was about 20 cm per sec.

In order to compare modern results of neural action potentials with the bioelectrical action potentials obtained by Burdon-Sanderson, it is not enough to identify the local negative potential transients but one must investigate the variation of the negative and positive after-potentials with instruments that will not produce distortions in these electrical transients.

Bioelectrical pulses, which as in Dionaea were found to last for several tenths of a second, can become highly distorted even if ordinary modern resistance-coupled amplifier circuits are used. It was found necessary to modify the differential-dc-amplifier described by Schmitt in order to adapt it for use as a dc amplifier if the direct-coupled stages of a Dumont 208 B cathode-ray oscillograph are to be used.

The connections between the metallic input circuit and the surfaces of the leaf were bridged by non-polarizable Ag-AgCl electrodes in 0.7 per cent KCl solution.

The stimulus to excite the bioelectrical activity, though not sufficient to produce mechanical closure of the trap, was applied by suddenly bending one of the trigger hairs. The resulting bio-electrical potential pulse was amplified distortionless and the oscillograph record was photographed by synchronizing the stimulus with the camera shutter.

The start of the action potential was gradual; there was no evidence of a sudden or explosive change although the initial acceleration was very great. The negative rising phase is smooth and its crest is reached in about 1/10 sec. The falling phase is much slower so that the peak as in neural spike potentials is situated well towards the side of the rising phase. Immediately following the spike, as in neuron compound action potentials, there occurs a negative after-potential, next comes the positive after-potential. The latter attains its maximum value in about 0.07 sec. and then decreases until restoration to its resting potential is completed in about 1.5 seconds.

If the action potentials were picked off at successively greater distances from the point of stimulation, the transients broaden and become lower. The compound action potential is resolvable into two components, one attributed to a transient comparable to the neural C-action-potential of unmyelinated mammalian nerve fibers and the other to the movement of an electrolyte associated with the hydrodynamic reactions of the lobes in closure.

Lantern slides made from the original oscillograph curves were used to illustrate the successive stages of the analysis.

A Study of the Permeability of Certain Epidermal Membranes to Gaseous Carbon Dioxide. W. M. DUGGER.

It has been generally understood by biologists that the exchange of gases between the internal tissue of plants and the external atmosphere only occurs to an appreciable extent when the stomates or other natural apertures are open. If this were true, closure of the openings, such as stomates, should largely prevent exchange of carbon dioxide between the plant tissue and the atmosphere.

Although there is considerable indirect evidence that epidermal walls are permeable to carbon dioxide, no comprehensive study of this matter has been previously undertaken.

The study that has been completed involves the use of non-stomated leaf, root and fruit tissue and the determination of their epidermal penetration by carbon dioxide using radioactive carbon as a tracer.

An enclosed gas release-flow-absorption method is described in conjunction with the results obtained.

In the leaf studies glass cups were sealed to the upper surface of the leaves of several species known to have stomates only on the lower leaf surface. Radioactive carbon dioxide in concentrations of 1, 5, and 10 per cent was circulated through these cups for a 4-hour period. The quantity of carbon dioxide penetrating the epidermal layers was determined by the use of Geiger counters and by radioautographs. Experiments were carried out with illuminated leaves and in darkness.

Similar experiments were performed with cup attached to the lower surface of leaves when stomates were closed and when stomates were open to determine the relative rates of penetration under those conditions.

The results of these experiments indicate that the amount of carbon dioxide diffusion through non-stomated epidermal membranes is a large fraction of the amount diffusing through the stomated epidermis.

In the root studies radioactive carbon dioxide was bubbled through the solutions in which roots of several species of plants were growing. The penetration of carbon dioxide into roots was determined by testing sections of roots with Geiger counters and by the use of radioautographs. From the results it is obvious that carbon dioxide gas does penetrate the uncutinized epidermal cells of roots. The majority of the gas remains in the gaseous phase in the intercellular spaces and can be easily removed by evacuation into a weak base.

The fruit studies involved the use of ripe and green tomato fruits. These were exposed to radioactive carbon dioxide in sealed containers for short periods of time. Sections of the fruit were tested by the usual method for the presence of radioactive carbon dioxide. The results indicate that the non-stomated epidermis of tomato fruit is permeable to carbon dioxide, a matter of considerable fundamental importance, particularly in relation to problems of storage of living plant tissues.

Tissue Activators of a Serum Enzyme. JESSICA H. LEWIS and JOHN H. FERGUSON.

A quantitative survey of a large number of animal tissue fractions, prepared by differential centrifugation, indicates a widespread distribution of a *fibrinolysokinase* (factor which activates serum prolysin to fibrinolysin enzyme). The "large granule" and "microsome" fractions (Claude) particularly show this activity and it is not extractible with ordinary solvents. A dog lung fraction (IV + VI) was selected for some special studies.

The tissue lysokinase is moderately heat labile and best preserved frozen at −20°C. It requires time for maximal effect on profibrinolysin and the rate of activation and final fibrinolysin yield are modified by temperature, concentration of kinase, deterioration of formed lysin, and by antilysin (if present). Serum and plasma are activated by tissue lysokinase with difficulty, but dilution lessens the "antilytic" effect. Antilysin is also demonstrable in some tissue fractions, but no prolysin. Human, dog, and bovine prolysins have been prepared free from antilysin and with little or no active lysin appearing either "spontaneously" or after treatment with chloroform (lack of a *serum* lysokinase?). When these three prolysins are tested with lung fractions from 8 species all are activated, in some degree, by most of the tissue lysokinase preparations, without evidence of the species specificity seen with the similarly-acting bacterial kinases. The successful, if partial (?), activation of bovine prolysin is noteworthy in view of previous inability to find a bacterial activator for this species.

The crude tissue preparations often contain factors which act on blood-clotting mechanisms, especially antithrombin and thromboplastin. By taking advantage of the greater thermolability of lysokinase and the "antithromboplastic" action of heparin, the thromboplastic and fibrinolysokinase activities of the tissue fractions can be separated experimentally.

Storage of Isolates of Pseudomonas solanacearum *under Mineral Oil in Relation to Virulence.* ARTHUR KELMAN and J. H. JENSEN.

Loss of virulence in culture is a characteristic of the plant pathogen, *Pseudomonas solanacearum* E. F. S., causal agent of southern bacterial wilt. An evaluation of the mineral oil method as a means of maintaining pathogenic cultures of this important parasite has been made over a four-year period. In 1945 virulent isolates were obtained from diseased potato, tobacco, and peanut plants. Stock cultures were made by covering 48-hour cultures of these isolates on potato-dextrose agar slants with a layer of sterile mineral oil (medicinal grade). Pathogenicity experiments were conducted at least once each year using sub-cultures of the original slants as the sources of inoculum. Eight or ten Marglobe tomato seedlings were inoculated by stem puncture for each isolate. Disease indices based on numerical rating of symptoms served as a means for comparison of relative pathogenicity in successive years. At periodic intervals comparison of stock cultures was made with new isolates obtained from diseased plants. In most instances virulence of inoculum from oil-covered isolates was comparable to that of these new isolates. In 1949 several cultures stored under oil for 4 years were only slightly less pathogenic than a fresh, highly virulent isolate obtained from

a diseased tobacco plant. The experiments demonstrated that virulence of *P. solanacearum* is relatively stable when stored for long periods of time on potato-dextrose agar slants covered with sterile mineral oil.

A Cretaceous Log-Jam. E. W. BERRY.

On Willis Creek west of North Carolina Route 87 in Cumberland County, North Carolina, there are exposed some 17 carbonized logs in place and numerous fragments. Most of the logs are carbonized with more or less pyrite; some are silicified, but only a few. The logs range in diameter from two to four feet. The longest one is exposed for 32 feet and bridges a tributary to Willis Creek. There is no set orientation, they point in all directions. On this same tributary are a series of beds inclined about 35° which are probably foreset beds. The region represents a delta in late Black Creek time (Upper Cretaceous).

A Megascopic Roundness Scale. M. C. POWERS.

A new roundness scale and a new technique of determining roundness have been proposed. Six class limits, instead of the previously used five, are used in this roundness scale. The new class limit occurs in the lower roundness values and is easily differentiated because of this position. The new term proposed was "Very Angular". A simpler method for determining the roundness value for a sedimentary sample is also proposed. This method has been used in laboratory work and found to be as accurate as other methods. It offers the advantages of six class limits over the previously used five. It does not necessitate the use of a comparison chart after the first 100 or so grains.

Some Geological Observations in Caldwell and Watauga Counties, Western North Carolina. T. R. GOEDICKE.

A description is given of the geology of an area of 20 square miles surrounding the property of the Yadkin Valley Ilmenite Co. in Caldwell County, based on a preliminary survey. A preliminary map shows approximate geological relations and contacts.

The metamorphic rocks of the area are of late pre-Cambrian age and consist of quartz-sericite phyllites, biotite gneisses and schists, amphibolites and quartzites. There are also large areas of granite gneiss, apparently a migmatite formed as the result of the invasion and absorption of the metamorphic rocks by magmatic ichors from depth.

In the northern part of the map area there occurs much blue slate of presumed volcanic origin, interbedded with quartzitic bands. It is believed that most of the foliated rocks were formed as the result of metamorphism of this series of volcanics and sediments. The regional schistosity has an average attitude of N 35° E and a dip of 50–60° SE.

The ilmenite occurrences of the area as well as the pegmatite dykes are thought to have originated a little later than the migmatites and to have come from an allied source.

A Discussion of Red Granites. GLENN E. MCKINLEY.

Several intrusions of red granite occur in the western part of the Wichita Mountains in southwestern Oklahoma. In many instances, distinction and correlation is difficult. This situation made it necessary to use a simple method of acid treatment of the granites which resulted in more positive identification of the various rock units.

The igneous rocks are Pre-Cambrian in age and outcrop as islands, with near horizontal Permian "red-beds" deposited in the hollows of the rugged erosional Pre-Cambrian surface. Successive granite intrusions are found cutting through an older basement of gabbro-anorthosite. They occur as sills and perhaps laccoliths. The area involved in a test of the acid treatment method is approximately seven hundred and fifty feet high and four square miles in area. At present eight granites have been recognized. All are leuco-granites with the exception of one which is a hornblende, biotite granite. Each rock type varies considerably in texture. This is particularly true of those having the greatest outcrop area. Because of the ever present red color, resulting from the presence of red or pink orthoclase and/or hematite staining, it is often impossible to distinguish rock types in a single outcrop by field examination alone. In the large outcrops one can usually establish the presence and relative age of the different granites by the standard dike and inclusion relationships. Difficulty arises when one leaves that outcrop and goes on to the next, particularly if the latter is some distance away and small. Identification and differentiation was attempted by utilizing heavy mineral separation, possible distinctions in texture and composition from thin sections and saw-cut slabs, all resulting in still uncertain correlation.

The acid treatment method was finally employed with noteworthy success. It involved selecting the freshest samples, crushing each to approximately five to ten millimeters, rinsing in distilled water and then placing in a four hundred milliliter beaker. The sample was allowed to fill about one-third of the beaker, which was then filled about two-thirds full of fifty per cent hydrochloric acid and boiled for at least four hours. Solution had to be added regularly and in several samples the iron content seemed so great that during the four-hour period such samples were rinsed and covered again with the fresh acid solution. Between eight and ten samples were checked during a setting by using a sand bath. Known samples were checked and without exception each recently mapped rock type from the larger outcrops (those in which the type and age relationship were felt to be certain) was found always to be primarily composed of only one of the following: red, flesh pink, or white orthoclase. Using this as a basis, smaller and more distant outcrops were sampled, checked in the laboratory, and mapped with greater certainty. In conclusion, this method was definitely an aid to correlation. It served as a means of subdividing the granites into one of three groups, depending on the true color of the feldspar.

Development of a Marine Annelid, Dasybranchus caducus, *from Egg to Pre-Adult.* C. G. BOOKHOUT.

Eggs are deposited in plum-shaped jelly masses, become ciliated embryos in

8 hours, and trochophores in 24 hours. The latter is characterized by two red eyes, apical tuft, and green pigmented bands between a prototroch and telotroch. At two days a neurotroch appears, and at three days larvae emerge from the jelly to become part of the plankton. They are positively phototropic and negatively geotropic. After 7 days they settle; at 9 or 10 days they lose their cilia and undergo metamorphosis. Development of fertilized eggs removed from the coelomic cavity show that jelly is not necessary for early development, nor does it hasten metamorphosis.

The best indication of age of larva and stage of juvenile is the condition of the setae. A notopodial and neuropodial winged seta develops simultaneously on each side in segments 2–4 at the 4th or 5th day. By the time of metamorphosis there are two winged setae per bundle in segments 2–4, and a single notopodial and neuropodial hooded uncinus on each side in segments 5–7. Post-larval development involves the occurrence of winged setae and the loss of uncini in thoracic segments. An increase in uncini in abdominal segments results in 4 tori per segment. The differentiation of sense organs, nervous system, digestive system and other internal organs is discussed.

Cytological Aspects of the Spinning Glands of the Parasitic Wasp, Habrobracon, from Feulgen Preparations. D. S. GROSCH.

The present report is based on whole mount preparations of male larvae and pupae of known age and determined size. The organisms were dissected in a rapid single operation using a pair of needles, immediately fixed with Gilson's fixative, and stained by the Rafalko modification of the Feulgen technique. Through these methods the delicate spinning or "silk" gland was often obtained intact and its distal bifurcation disclosed (branched structure was omitted from a diagram previously published in this Journal **65**: 62). Although anteriorly the structure may appear more than once per transverse section due to its sinuous arrangement, posteriorly its two or even more appearances per transverse section are traceable to the bifurcation.

Cytological details, some of them unexpected and surprisingly similar to situations found in ciliated protozoa, were discovered as follows:

(1) Organization at the cytological level is not based on a uninucleate cell. Units containing four large nuclei predominate in glands of mature larvae. Occasionally a 5- or 6-nucleate unit can be found. This is in comparison to the situation in first instar larvae where the units not quadrinucleate contain 2 or 3 nuclei.

(2) Amitotic divisions of nuclei are seen in first and second instar larvae, which suggests the method whereby the quadrinucleate units are constituted. However, the total number of nuclei in a spinning gland is found to be over 400 in first instar larvae and between 450 and 500 in mature larvae indicating little amitotic nuclear division during larval development. Therefore it is proposed that the major organization of structural units in the SG occurs in the embryo or during the hatching period. In fact no more than one amitotic figure per gland has been seen on any single slide of a young larva.

(3) On the other hand, during degeneration of the gland (larva in cocoon) amitotic division followed by nuclear fragmentation is general.

(4) The duplication of nuclear contents during the tremendous growth in nuclear size attending larval development resembles endomitotic processes.

(5) Nuclei in full-sized larvae contain a large number of small stainable elements which become clumped accompanying nuclear vacuolization when larvae assume spinning activities. Ultimately the individual objects of the clumps become indistinguishable. Similar events occur in the nuclei of other larval structures destined to undergo histolysis but the inception is later than in the spinning gland, hence the contrast in nuclear situations depicted in the Journal of Morphology 86: 153–176, 1950.

A Preliminary Study of Lens Regeneration in Pseudacris nigrita feriarum. EDWARD C. HORN.

The ability of larval *Pseudacris nigrita feriarum* to regenerate a lens from the dorsal margin of the iris (Wolffian regeneration) was tested by removing the left lens at five different stages during the development of the tadpoles. The earliest stages tested (Shumway 24) showed the opercular folds just closing; the latest (Taylor and Kollroe VI) possessed a paddle-shaped hindlimb bud without demarcation of toes.

The operated animals were killed at intervals up to the tenth day after operation for the youngest operative stages and up to the twentieth day for the oldest stages. Stained serial sections of the head region of each experimental animal were made.

Within the time limits listed above for the stages used the data indicated that no regeneration from the iris had occurred. In the few cases which showed regeneration of a lens, the rapidity with which a new lens formed and its position in the eye indicated its source from lens fragments formed at the time of operation rather than from the iris margin.

The Inheritance of Ectrodactylism. Part II. Statistical Tests of Alternative Hypotheses of its Inheritance. CHARLES D. HOWELL.

Fifteen affected individuals had 44 normal sibs, making a total sibship of 59 persons. In 13 families, not one parent of affected children was affected. Four affected parents had 12 normal, but no affected children.

A recessive gene was first considered as responsible for the trait. Making a correction for over-selection of recessives, it was found that 21 affected would have been expected instead of 15. The difference is large, but 20% of data at random could be expected to have as big a deviation. There were 10 marriages of unrelated parents with affected children out of about 1,000 marriages of the descendants of the apical progenitors of the family. These marriages of carriers would be expected in 4 of 100,000 marriages if the trait were recessive and seen in 1 in 100,000 of the population. The 1/100 observed is much too high.

Next, the possibility that a dominant gene with low penetrance is involved was considered. In this case the appearance of the trait would hinge upon the frequency of the gene only in descendants of the apical progenitors and would not involve the frequency outside the family. Every affected individual found was a descendant of one couple. Penetrance of 50%, 25% and 12.5% were successively

considered. The first two did not fit all the observed facts, but 12.5% fitted well all three categories as follows: (1) sib ratio—expected 16 affected, 43 not affected; observed: 15:44. (2) Frequency of the trait in parents of affected children—expected 1.6 out of 13 pairs; observed 0 out of 13. (3) Frequency of the effect in children of the affected parent—expected 0.75 in 12; observed 0 out of 12.

Unless population studies reveal this trait as being much more common than we now suspect, the assumption of dominance with low penetrance has an advantage over simple recessiveness in accounting for the appearance of the trait in the families observed.

Phosphorus Exchange in the Shell of the Oyster. LOUISE H. JODREY and KARL M. WILBUR.

Shells of the oyster, *Ostrea virginica*, when placed in sea water containing radioisotopes exchange atoms in the shell for labeled atoms in the solution. Ion exchange must be considered as a factor in shell formation and has been studied using radioactive phosphorus.

The amount of P^{32} exchanged is not uniform over the inner surface, certain areas consistently showing greater exchange than others. In all areas P^{32} deposition at first rises rapidly and then reaches an equilibrium. When the radioactive shells are placed in non-radioactive sea water, the removal of P^{32} proceeds in a similar manner, falling rapidly at first and then reaching an equilibrium. However, all the P^{32} is not removed in the same period required for its deposition. Apparently a portion of the radioactive phosphorus has been changed to a non-labile form.

Deposition of P^{32} was compared at 10° and 38°C. At the higher temperature the rate and extent of deposition are considerably greater; and, in contrast to shells at 10°, equilibrium is not usually reached in a 40-hour experimental period. The exchange is reversible at 10°, whereas a non-labile form is produced at 38°. The existence of a temperature coefficient and the formation of a non-labile form of phosphorus indicate the presence of some process other than simple exchange.

Experimental Production of Pulmonary Artery Anomalies in Chick Embryos. M. W. JOHNSON and L. J. MANHOFF, JR.

The causes which determine differences in embryonic blood vessel disposition are of interest to biologists.

A direct experimental method of duplicating certain spontaneously-occurring anomalies should be of value for (a) determination of developmental steps leading to adult patterns and (b) furnishing adequate numbers of specific anomalies for study of possible corrective surgical procedures.

A method is described by which certain pulmonary artery anomalies are produced. Electric coagulation of the right 6th visceral arch tissue in chick embryos (age—77 hrs.) results in either stenosis of the right pulmonary artery or a complete absence of it. In the latter case, blood supply of the right lung may be through a branch from the systemic arch.

Further use of this experimental method for attack on other problems is discussed.

REINARD HARKEMA, *Secretary*

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY 1949–1950

474TH MEETING, OCTOBER 11, 1949

ALFRED T. BRAUER (Mathematics): *Limits for the Characteristic Roots of a Matrix.*

H. G. BAITY (Sanitary Engineering): *A Sewage Disposal Plan for the City of Montevideo, Uruguay.*

This paper describes the investigations which were made to develop a suitable system of sewage collection and treatment at Montevideo, Uruguay, to relieve the present pollution and avert future damage to the water-front developments of this area, which constitute one of the most important resources of that country.

475TH MEETING, NOVEMBER 8, 1949

NATHAN ROSEN (Physics): *Gravitational Waves.*

MAURICE WHITTINGHILL (Zoology): *An Investigation of Changes in Gene Linkage Values by the Use of Gamma Rays.*

In genetics the tendency for transmitting some genes in the parental assortments (linkage) comes from the fact that these genes are in the same chromosome. New combinations may be formed by crossing over, which has been attributed to exchanges occurring during meiosis. Some external agents alter the values of the recovered exchange products, chief among them X-rays and temperature extremes. In Drosophila males the crossovers induced by these agents originate before meiosis. The distribution of these exchanges in males is concentrated toward the spindle attachment, as shown in my recently computed spermatogonial map. This may also apply to the other sex and explain the altered crossover values there found. Several experiments were performed while the author was a research participant at the Biology Division of the Oak Ridge National Laboratory to test the ability of another mutagenic agent, gamma rays, as an inducing agent and to try to find the *modus operandi*. After irradiation with 4000 r crossover values were increased regularly throughout the major length of the chromosome, greatest near the spindle attachment, in a pattern already known for high temperatures and other agents. In addition, coincidence values for each region were computed from the multiple crossovers and were found to have increased in all regions as follows: very slightly in the most distal regions, progressively more in regions nearer the spindle attachment, and greatest of all in the spindle region. These two findings were what had been predicted on the hypothesis that some of the crossings over were induced in oögonial cells before the usual time for spontaneous crossing over. Furthermore, there was a slight amount of clustering of different kinds of crossovers in different families. Induced clustering was then reinvestigated in experiments with two special stocks whose synthesis and use in the author's "autoclassifying" crossover-selector system has been described before this Society. From gamma-irradiated Star Lobe[4]/Curly

Pufdi females the clustering was of an extreme sort which could be expected only in 1/1000 experiments if resulting from independent meiotic formation. Much more probably such a distribution of crossovers among families was the result of a little oögonial crossing over and multiplication in varying amounts. Similar irradiation of Minute-y Glued/Stubble bithorax^D males was followed by the appearance of clusters of crossovers which were clearly of spermatogonial origin. Gamma rays thus appeared to have acted directly upon gonial cells in the two special stocks and probably also in regular rucuca heterozygotes.

476TH MEETING, DECEMBER 13, 1949

R. C. MITCHELL (Geology): *Concerning the Core of the Earth.*

The core of the Earth represents about 0.4 of the total radius, the periphery being considered to lie at a depth of 2900 km.

The studies of R. D. Oldham first yielded scientific data regarding the core. Between 90° and 150° from the point of origin of earthquakes, he found that S and P waves underwent a marked decrease in velocity of propagation, the rate of decrease of the former type of wave being greater. Of the two suppositions regarding the S waves, Oldham categorically denied that such waves were extinguished in the core.

Later work by Gutenberg and others showed that the 'shadow zone' lies between 102° and 143°, and that waves refracted through the core can arrive at any point more distant from the locus of origin than about 143°. These waves are the P′ ones, condensational waves of greater energy than P waves.

The problem of the S waves resolves itself into two schools of thought. One school maintains that from certain earthquake records, they definitely have established the occurrence of shear or S waves, and from this, postulate that the core is solid. The other school argues that the core is liquid, as no S waves penetrate it. The decision regarding the physical state of the core must be left to the future.

The core consists of 90% Fe, 5% Ni, .76% Cu and .57% Co, some 27 other elements comprising the remainder. It is the high percentage of the heavy metallic alloys which account for the 77% of the total Earth mass, whilst the silicate shells total only 23%.

Certain interesting speculations can be made from studies of the core: (a) If there is no sudden increase in density at the core boundary, perhaps convection within the core may be responsible for terrestrial magnetism. (b) It would be of great value to test instrumentally if there is a 'lag' in the axis of rotation of the core with respect to the mantle in the Earth's precession, for if such is so, then the characteristics of seismic waves would be altered and our concepts must be changed accordingly. (c) With increase in depth, likely the melting point increases more rapidly than the temperature, and hence temperatures at depth would prevent crystallization, hence solidification, hence rigidity. The importance of such in petrological theories, such as magma genesis, magmatic movements, magmatic eruptions, etc., may indeed have interesting implications.

LYTT I. GARDNER, M.D. (Biochemistry): *The Effect of Dietary Phosphate Load on the Newborn Infant.*

Review of 16 cases of neonatal tetany revealed that all were fed cow's milk formulas. Analyses of human and cow's milk confirmed previous data that cow's milk has a high concentration of P and a low Ca/P ratio. Breast fed newborns showed little variation in daily serum inorganic P determinations, but cow's milk fed infants showed levels of serum P and Ca similar to values found in neonatal tetany, with maximum P values on the 6th to 8th day of life. The per square meter P intakes of newborns fed cow's milk exceeded that of the average adult, and were within the range known to cause elevated serum P and depressed serum Ca and Mg values in dogs. The association of cow's milk ingestion with neonatal parathyroid hyperplasia is suggested by a correlation of Kaplan's histological study of newborn parathyroids with diet ingested by infants of his series (cf. Arch. Path. **34**: 1042, 1942). Complete metabolic data on a cow's milk fed newborn showed elevation of serum P, depression of serum Ca and Mg, and marked increase in urinary P as compared to the breast fed newborn. When Ca lactate was added to the formula serum P, Ca and Mg returned to normal. Balance data showed more positive Ca and less positive P, Mg and N balances than in the pre-Ca lactate periods. When added Ca was withdrawn these balances returned to foreperiod levels, and serum Ca and Mg values again fell. Renal P clearance in face of increased serum P with dietary P load in the first week of life was found to be less than 10% of reported glomerular filtration rate for the newborn. These findings point to the high P content of cow's milk as a major etiologic factor in many cases of neonatal tetany and emphasize the suitability of human milk for the human newborn.

477TH MEETING, JANUARY 10, 1950

OSCAR K. RICE (Chemistry): *Thermodynamics of Liquid Helium.*

Gaseous helium condenses at atmospheric pressure, at a temperature slightly above 4°K, to a liquid whose properties appear to be entirely normal. At 2.19°K, the so-called λ-point, however, it undergoes a remarkable transformation. This is a second-order transition, which has no latent heat and no change in volume. The specific heat, however, rises to a large value, has a discontinuity, and then below the λ-point, falls off rapidly. The coefficient of expansion also shows a discontinuity. The flow properties of liquid helium show a remarkable change below the λ-point. The liquid practically loses its viscosity, and becomes a "superfluid". It flows over the surfaces of glass containers. It becomes a highly efficient conductor of heat.

About twelve years ago London suggested that these properties were connected with the fact that helium atoms obey the Bose-Einstein statistics. The λ-point transition was assumed to have a connection with the fact that in a Bose-Einstein ideal gas there should occur a special type of condensation in momentum space, in which a finite fraction of the molecules goes into the lowest energy level. This seems to be confirmed by the properties of the recently investigated isotope,

He^3, which obeys the Fermi-Dirac statistics, and hence should not show any effects which can be connected with the Bose-Einstein condensation. That this is true has been verified down to about 1°K.

On the basis of London's theory, it was suggested by Tisza, and later on other grounds by Landau, that below the λ-point helium consists of a mixture of two phases, one of these being ordinary liquid helium such as is known above the λ-point, and the other superfluid in essentially the state in which it exists at 0°K. This hypothesis was found to be capable of explaining many of the peculiar properties of liquid helium.

The present discussion deals principally with the thermodynamics of liquid helium in the light of the two-fluid theory. In particular the thermodynamic consequences of assuming these two phases to be in equilibrium are discussed. It is pointed out that there is some evidence that these phases are separated in ordinary space as well as in momentum space. The specific heat just above the λ-point is considered on the assumption that in this region superfluid is beginning to appear in the form of small globules; it is estimated that these globules contain around 60 to 80 helium atoms The thermodynamic properties below the λ-point are used to estimate the entropy of mixing of the two fluids in this region. The results suggest that in this region the superfluid forms a "partially condensed system", having possibly a fibroid structure. The nature of the second-order transition at the λ-point is considered in the light of this picture. A new relation is derived for the change of the λ-point with pressure, and the change with concentration of the isotope He^3 is also considered. The thermodynamic results, though discussed in the light of the hypothesis that the two phases separate in ordinary space as well as momentum space, depend for the most part only on pure thermodynamics and the mere existence of two phases.

CHARLES W. HOOKER (Anatomy): *Blood Levels of the Ovarian Hormone, Progesterone.*

Although the hormones are considered to be blood-borne regulators of various bodily functions, information with respect to concentrations in the blood is scanty. In collaboration with Dr. T. R. Forbes at Yale University a bio-assay has been developed that regularly detects 0.0002 microgram of the ovarian hormone, progesterone. The test is specific in the sense that twenty-odd related compounds failed to provoke the response upon which the test is based.

A study of blood of the rabbit, the mouse, the monkey, and man revealed that the hormone is present only in the plasma, that roughly 90 per cent is free and 10 per cent bound or conjugated, and that in the presence of an active corpus luteum a plasma concentration of the order of 6.0 μg/ml is typical.

During pregnancy in the mouse, a relatively high level of plasma progesterone was found in the first nine days. Thereafter the level fell steadily, except for a sharp rise and fall on the thirteenth and fourteenth days. A physiologically ineffective level was found during the three days preceding delivery. The assumption has usually been that the blood level rises steadily throughout pregnancy and falls off sharply at parturition.

In the monkey low levels were found during the first half of the menstrual cycle. A transitory increase occurred at the middle of the cycle. During the latter half of the cycle a comparatively high level was found. At the onset of menstruation the blood level decreased sharply.

With respect to the metabolism of progesterone, it has been found that the bound fraction in plasma is biologically inert and that binding is at least one of the mechanisms of hepatic inactivation of progesterone in the mouse. Other sites of inactivation were found to be the kidney and the blood plasma itself. Upon circulation through the kidney blood lost 14 to 97 per cent of its progesterone. The progesterone was not excreted as such or as pregnanedial. Evidence was obtained that blood plasma contains an enzyme system that converts progesterone into another compound.

478TH MEETING, FEBRUARY 14, 1950

J. J. WRIGHT and C. G. SHEPS (Public Health): *The Present Status of Syphilis Control in the United States.*

E. D. PALMATIER (Physics): *Cosmic Rays at Low Altitudes.*

The genetic relationship between the soft (electronic) component and the hard (mesonic) component of cosmic radiation at sea level was discussed, the essential part of the picture being that the soft component arises primarily as a secondary radiation of the hard component. The principle techniques of using a Geiger counter telescope to separate these components were explained.

An accurate knowledge of the intensities of these different components is of importance, for it enables us to obtain some idea of the meson decay process in which electrons are produced. The results of the author's work supported the picture that the mu meson decays into an electron and two non-ionizing particles the nature of which is as yet unknown.

479TH MEETING, MARCH 7, 1950

T. F. HICKERSON (Mathematics): *String Lining Railroad Curves for Smoother Riding.*

Under the impact of traffic, railway track tends to creep slowly out of line. This irregularity may become noticeable, particularly on curves where the lateral shock and sway in the high speed trains is unpleasant to passengers.

The trend toward higher speeds for both freight and passenger operation makes it more important than ever to maintain the track continuously in good alignment.

A simple method for securing a smooth riding curve, known as "string lining," has become standard practice during recent years. Four steps enter into the procedure:

1. Marking the outer rail at equal intervals (called stations) throughout the curve.
2. With a strong linen fishing line, of length equal to two stations, measure the middle ordinates at each station in turn.

3. Adjust the measured middle ordinates (called ordinates) to determine the inward (or outward) "throw" of the track at each station for uniformity of ordinates. It is desirable that the ordinates along the central (circular) portion of the curve be *equal*, while those along the approach and run-off curves should vary by equal increments from a full ordinate at the point of full curvature to a zero ordinate at the tangent.

4. Setting stakes for establishing the new positions of the track.

The sum of the adjusted ordinates and the original (measured) ordinates for any one curve should remain the same. But a great number of sets of adjusted ordinates may satisfy this requirement. These have been found by numerical cut-and-try tabulations that may necessitate a number of trial solutions.

The aim of this paper is to present the algebraic background of the factors involved so that the effect of a change in an ordinate at any station on the "throw" at a subsequent station may be formulated. Accordingly, after having written out a desirable set of ordinates, one may calculate the theoretical "throws" that will bring about this condition. It is usually necessary that the resultant throws at the initial and final stations (those on the tangents) should be zero. If the final calculated throw (an accumulated quantity) on the tangent is not zero, then it can be reduced to zero in one operation by a change in two or more preceding ordinates.

Let m_1', m_2', m_3', m_4', etc., represent the original (measured) ordinates at stations, 1, 2, 3, 4, etc., while m_1, m_2, m_3, m_4, etc., are the corresponding "adjusted" ordinates at these stations, and the differences d_1, d_2, d_3, etc., are:

$$d_1 = m_1 - m_1', \; d_2 = m_2 - m_2', \; d_3 = m_3 - m_3', \text{ etc.}$$

Let t_1, t_2, t_3, t_4, etc., represent the "throws" at stations 1, 2, 3, 4, etc., while Δm, Δd, and Δt are the respective changes in m, d, and t at any station.

Making use of the geometrical principle "a line joining the midpoint of two sides of a triangle is equal to one-half the third side," it follows that a throw at any station will produce a change in the ordinates at the two adjacent stations equal to one-half the throw, and of opposite sign.

Hence

$$m_1 = m_1' + t_1 - \tfrac{1}{2}t_2, \quad (1)$$
$$m_2 = m_2' + t_2 - \tfrac{1}{2}t_1 - \tfrac{1}{2}t_3, \quad (2)$$
$$m_3 = m_3' + t_3 - \tfrac{1}{2}t_2 - \tfrac{1}{2}t_4, \text{ etc.} \quad (3)$$

Then

$$d_1 = m_1 - m_1' = t_1 - \tfrac{1}{2}t_2, \quad (4)$$
$$d_2 = t_2 - \tfrac{1}{2}t_1 - \tfrac{1}{2}t_3, \quad (5)$$
$$d_3 = t_3 - \tfrac{1}{2}t_2 - \tfrac{1}{2}t_4, \text{ etc.} \quad (6)$$

And then if $t_1 = 0$, we have

$$t_2 = -2d_1 \quad (7)$$
$$t_3 = -4d_1 - 2d_2 \quad (8)$$
$$t_4 = -6d_1 - 4d_2 - 2d_3, \text{ etc.,} \quad (9)$$

In general,

$$t_n = 2(n-1)d_1 - 2(n-2)d_2 - \ldots -2d_{n-1} \tag{10}$$

Letting Δd_k and Δd_p represent the changes in the d's at stations k and p respectively, then the change in t at the nth station is

$$\Delta t_n = -2(n-k)\Delta d_k - 2(n-p)\Delta d_p \tag{11}$$

Thus if $\Delta d_k = +1$ and $\Delta d_p = -1$, Δt_n (the change in the throw at station n) becomes

$$\Delta t_n = -2(n-k) + 2(n-p) = 2(k-p). \tag{12}$$

W. H. HARTUNG and H. D. SMITH (Pharmacy): *The Odors of Diarylalkanes.* (Published in this issue)

480TH MEETING, APRIL 11, 1950

J. C. MORROW (Chemistry): *Low Temperature Heat Capacity and Entropy* of $K_3Co(CN)_6$ and $K_3Fe(CN)_6$.

The heat capacities of $K_3Fe(CN)_6$ and $K_3Co(CN)_6$ have been measured from 15° to 300°K. $K_3Fe(CN)_6$ exhibits an anomaly with a maximum near 131°K. The estimated entropy change for this non-isothermal transition is 0.91 ± 0.20 cal/deg/mole. The transition is ascribed to change in population of electronic energy levels. For crystalline $K_3Fe(CN)_6$, the entropy at 298.16°K is 100.86 ± 0.20 cal/deg/mole. The entropy of crystalline $K_3Co(CN)_6$ at 298.16°K is 96.00 ± 0.20 cal/deg/mole.

W. R. STRAUGHN (Bacteriology): *Mechanism of Action of Antihistaminics in a Bacterial System.*

Growth of *Klebsiella pneumoniae* in a synthetic salts-glucose medium was greatly stimulated by small amounts of histamine ($25 - 100 \times 10^{-5}$M). Pyribenzamine, under the test conditions, completely inhibited growth at a concentration of 200×10^{-5}M and was partially inhibitory at concentrations of 25 to 100×10^{-5}M or less. Results obtained when histamine and pyribenzamine were combined in various proportions indicated that the pyribenzamine inhibition is not a competitive one. Constant ratios of histamine and pyribenzamine did not yield equal growth inhibitions or stimulations. Similar results were obtained with histidine in place of histamine and also using histadyl as the antihistaminic.

481ST MEETING, MAY 9, 1950

S. A. VORA (Mathematical Statistics): *Bounds on the Distribution of Chi-Square.* (This was the Coker Award paper.)

VICTOR A. GREULACH (Botany): *Maleic Hydrazide as a Plant Growth Inhibitor.*

Although maleic hydrazide was synthesized by Curtius and Foesterling in 1895, it was not until 1949 that Schoene and Hoffman reported that this substance, used in concentrations of around 2000 p.p.m., would strongly inhibit

plant growth without causing marked injury or death of the plants. Following this discovery a number of botanists and other plant scientists initiated experiments designed to secure additional information on the rather unique effects of maleic hydrazide on plant growth. In the paper presented to the Society the literature was reviewed, but in this abstract a resumé will be given of only the work which has been done in the laboratories of the Department of Botany at the University of North Carolina.

The writer found that maleic hydrazide inhibited the growth of tomatoes, lima beans, peas and wheat, and that the use of a wetting agent did not increase its effectiveness except with wheat. The tomatoes were younger when treated than were those of Schoene and Hoffman, and the growth inhibiting effects were much more marked than they observed. In both tomatoes and sunflowers the maleic hydrazide inhibited the lateral as well as the terminal growth of the stems. The tomatoes developed abundant anthocyanin on the under sides of their leaves, and the leaves were much smaller and less highly divided than usual.

In experiments conducted by the writer and Earlene Atchison it was found that maleic hydrazide inhibited the growth of onion roots suspended in it by inhibiting mitosis, but apparently not cell elongation.

In another group of experiments conducted by the writer it was found that older tomato plants were not inhibited as much in growth as the younger ones used in the first experiment and that 500, 1000 and 2000 p.p.m. inhibited growth, while 1, 10 and 1000 p.p.m. had no significant influence on growth. The three higher concentrations also inhibited reproductive development, and 1000 and 2000 p.p.m. completely inhibited fruit, but not flower, formation. A 1000 p.p.m. solution of maleic hydrazide inhibited the growth of the stems, but not of the hypocotyls, of etiolated bean plants, but concentrations of 1, 10 and 100 p.p.m. had no effect.

In other experiments it was found that maleic hydrazide applied to a single leaf of lima bean and squash plants inhibited growth of the plants, as was also the case when maleic hydrazide was injected into the pith cavity of the first internode of squash plants. These results indicate that maleic hydrazide is translocated by the plant to the terminal bud, where the growth inhibition occurs. Further evidence along this line is derived from the fact that tomato seedlings were completely inhibited in growth when maleic hydrazide was placed on the sand culture media in which they were growing.

Sidney Johnson, a graduate student, found that maleic hydrazide caused neither positive nor negative curvatures of *Avena* coleoptiles, providing additional evidence that maleic hydrazide inhibits cell division rather than cell elongation. He also failed to find any inhibiting effect of maleic hydrazide on various bacteria, fungi, or algae, nor did it inhibit the growth of mice or mice tumors. Although preliminary, these results indicate that the growth-inhibiting effects of maleic hydrazide may possibly be restricted to the higher plants. Another graduate student, Miss Winifred Compton, is conducting an extensive study of the effects of maleic hydrazide on mitosis and cell enlargement in pea seedlings.

Dr. O. K. Rice, Chairman of the Nominating Committee, presented the following:

President—D. P. COSTELLO (Zoology).
Vice-President—P. E. SHEARIN (Physics).
Associate Editor of the Journal—G. R. MACCARTHY (Geology).

The above officers were unanimously elected.

A. E. RADFORD, Sec.-Treas.

HERPETOLOGICAL NOTES FROM EASTERN NORTH CAROLINA[1]

By William B. Robertson and Edwin L. Tyson

This report is based upon collections of amphibians and reptiles made in eastern North Carolina during the summer of 1948. The junior author and Mr. Lester Harris collected in Pitt County (in the vicinity of the former's home near Greenville) on several dates between June 19 and July 1, and intensively from July 7 to 20. This work was done as part of a field course for Washington Missionary College, Takoma Park, D. C., and the specimens were deposited there. From July 22 until September 3 the authors attended the Duke University Marine Laboratory at Beaufort. Opportunity was taken during this time to collect at several localities in Carteret County, North Carolina, with special effort being made to investigate the herpetofauna of the offshore banks. Collections were made August 18 on Core Bank at Cape Lookout, and August 21 on Shackleford Banks. Additional short periods were spent in collecting around Mullet Pond, Shackleford Banks, on several other occasions. On August 28 and September 4 and 5, collections, consisting largely of salamanders, were made at cypress swamp localities in Pitt County. Additional specimens were secured by the junior author in the spring and summer of 1949.

Little previous work has been done in the Pitt County region of eastern North Carolina, where our collecting centered. The most recent account of the herpetology of the state (C. S. Brimley, 1939–1943) gives definite Pitt County records for only nine species: *Eurycea longicauda guttolineata*, *Plethodon c. cinereus*, *Scaphiopus h. holbrookii*, *Bufo t. terrestris*, *Pseudacris brimleyi*, *Pseudacris n. nigrita*, *Pseudacris ocularis*, *Elaphe obsoleta quadrivittata*, and *Clemmys guttata*. Brandt (1936) adds *Hyla femoralis* to this list. Brimley (op. cit.) mentions 18 additional species as occurring generally over the state, or throughout the coastal plain: *Amphiuma means*, *Eurycea bislineata cirrigera*, *Desmognathus fuscus auriculatus*, *Plethodon g. glutinosus*, *Bufo woodhousii fowleri*, *Hyla crucifer*, *Hyla v. versicolor*, *Rana clamitans*, *Rana catesbeiana*, *Anolis carolinensis*, *Sceloporus undulatus hyacinthinus*, *Leiolopisma laterale*, *Eumeces fasciatus*, *Coluber c. constrictor*, *Lampropeltis g. getulus*, *Thamnophis o. ordinatus*, *Agkistrodon c. contortrix*, *Chelydra s. serpentina*, and *Terrapene c. carolina*. These are thus included in the fauna of the county by inference, but it is not likely that Pitt County specimens of many of them have been collected. It is obvious from the above lists that previous collecting in the county has been of a casual nature. The present report confirms twelve of the species listed from the general area but not definitely from Pitt County, and adds records for 20 additional species and subspecies not mentioned above.

Pitt County lies in the lower North Carolina coastal plain on both sides of the

[1] Contribution from The University of Illinois Natural History Museum and the Department of Zoology, University of Illinois; and the Department of Zoology, State College of Washington.

Tar River. The smaller streams of the county, with the exception of Little Contentnea and Swift creeks, flow into the Tar River. These two creeks, along the first of which much of our collecting was done, drain southward into the Neuse River. The topography and vegetation are typical of the coastal section. Wells' (1928) account of vegetational succession in the coastal plain is applicable to the area. Uplands not in cultivation are at various stages in the old field succession, or in pine or oak-pine woods. Bottomland tracts along the Tar and Neuse rivers, and their tributaries, are occupied by extensive cypress-gum swamps (*Taxodium distichum*, *Nyssa aquatica*, and *N. biflora*). Collecting in uplands was generally poor, due, at least in part, to the prevailing summer drouth. A few snakes, notably *Lampropeltis g. getulus*, *L. calligaster rhombomaculata*, *Coluber c. constrictor*, and *Crotalus h. atricaudatus*, were taken in pine woods or along roads adjoining them. In the swamps, collecting was more successful, especially in late summer when low water levels allowed access to many normally flooded sites.

The collection here reported contains 127 specimens representing 42 species and subspecies. Examples of two additional species were seen, but no specimens obtained. These are distributed as follows: salamanders, 44 specimens of seven species; frogs and toads, 40 specimens of eight species; lizards, 13 specimens of five species; snakes, 21 specimens of 17 species; turtles, nine specimens of five species. Included are 24 specimens from Carteret County, three from Greene County, one from Hyde County, and 99 from Pitt County.

The authors wish to express their appreciation to Dr. Hobart M. Smith for advice and encouragement given throughout the preparation of this paper, and for the use of his herpetological library. Drs. L. M. Ashley and D. M. Brown of Washington Missionary College, and Dr. Joseph R. Bailey of Duke University merit our thanks for their kind cooperation in making specimens from the collections of their respective institutions available to us for study. Dr. W. L. Engels of the University of North Carolina graciously allowed examination of specimens of *Natrix sipedon engelsi* from his personal collection. Specimens listed as "WMC" are at Washington Missionary College, Takoma Park, District of Columbia; other catalogue numbers refer to specimens in the Museum of Natural History, University of Illinois, unless otherwise specified.

CAUDATA

Amphiuma means Garden. Congo eel.

A single specimen (WMC) was taken at night ten miles west of Greenville, Pitt County, from a small stream in a marshy pasture. The species is recorded by Brimley (1939) as common in the coastal region, but it has not previously been definitely listed for Pitt County.

Desmognathus fuscus auriculatus (Holbrook). Dusky salamander.

Twenty-three specimens were obtained in Pitt County: two (WMC; 5204) from Little Contentnea Creek, ten miles west of Greenville on September 4,

and a series of 21 (12, WMC; 5180–88) from Chicod Creek, near Grimesland, on September 5.

This species was the most abundant salamander along the muddy streams in cypress-gum swamps. At the Grimesland locality several individuals were found under or in almost every log investigated.

Since Bishop (1943, p. 195) states that little is known of the breeding habits of this subspecies, our observations of six nests found at the above locality may be worthy of note. The globular egg-masses comprising from 14 to 20 eggs (as nearly as they could be counted *in situ*) were located in cavities *within* well-rotted cypress logs and stumps. All contained active larvae about ready to emerge. In all cases logs and stumps housing nests were located immediately at the edge of Chicod Creek or of small pools connecting with the creek. Females were found curled around all egg masses except one. These "brooding" females made no effort to escape, in marked contrast to the behavior of other individuals. Placement of the eggs appears to differ from the usual habit of *D. f. fuscus* and *D. f. brimleyorum* both of which are reported to deposit eggs under stones or logs, or occasionally under loose moss or bark on fallen logs (Bishop, 1941, p. 316).[2]

Brimley (1939) reports the present subspecies from "... the whole state east and south of Raleigh." Pitt County, however, seems to mark the approximate northern limit of occurrence of typical *auriculatus*, since Dunn (1926, p. 93) regards a specimen from Lake Drummond (extreme southeastern Virginia) as a *fuscus-auriculatus* intergrade. In North Carolina Dunn (*loc. cit.*) reports intergrading populations from Raleigh, Wake County, Kinston, Lenoir County, and Magnolia, Duplin County; and (*op. cit.*, p. 101) typical *auriculatus* from Grimesland, Pitt County, and four other localities in coastal counties of southeastern North Carolina.

Examination of our series of 23 adults, ranging in length from 57 to 101 mm., seems to confirm the allocation of Pitt County specimens to *D. f. auriculatus*. Considerable variation exists in the series in the amount of ventral pigmentation shown, and in the intensity of the dorsal ground color, but comparison with specimens of *D. f. fuscus* from New York, Maryland, southern Indiana, and southern Illinois shows the Pitt County specimens to be generally darker. The most distinctive feature separating them from *D. f. fuscus* seems to be the patterns of spotting (orange-red in life) on the back, tail, and sides of the body. The features of the typical patterns and variations present in our series are as follows:

1) There is a double row of large dorsal spots usually one costal space in width and separated by one or two costal spaces. Behind the hind legs these rows merge to form a single stripe along the tail keel. This pattern is best shown in smaller adults, but is well-developed on several of over 90 mm. length. In a few small specimens of under 70 mm. the spots are joined to form dorsal stripes.

[2] Since work on this report was begun, an account of one nest of *D. f. auriculatus*, in Richmond County, Georgia, has been published (Neill and Rose, 1949). This nest was located in a shallow soil depression under a scrap of bark, a situation similar to that sometimes used by *D. f. fuscus*. It contained only six eggs.

2) Another double row of light spots is discernible on each side from behind the front legs to the middle of the tail. These are present on all specimens except a few brightly marked individuals in which the upper row is largely incorporated with the expanded dorsal spots.

3) The color and width of the orbitotemporal "desmognath" mark varies greatly in our series. In specimens showing high development of the above dorsal and lateral pattern, it is wide and of similar orange-red color. In most of the specimens the stripe is narrow and lighter, while in the darkest individuals it is completely obscured.

No approach to the above described patterns was found in specimens of *D. f. fuscus* examined.

Plethodon glutinosus glutinosus (Green). Slimy salamander.

Six specimens of this species (4, WMC; 5189–90) were collected at Little Contentnea Creek, ten miles west of Greenville, Pitt County, on September 4. All were found under logs on slopes above a cypress swamp.

Stereochilus marginatus (Hallowell). Margined salamander.

Four specimens were collected at two Pitt County localities: two (WMC; 5191) from Little Contentnea Creek, ten miles west of Greenville on August 28, and two (WMC; 5192) from Chicod Creek near Grimesland on September 5. All specimens were found under logs in extremely muddy, recently flooded areas of cypress swamp. These specimens are the first reported for Pitt County, Brimley (1939) having recorded the species from similar habitats in other coastal-plain counties.

The four specimens respectively measure 84, 86, 90, and 95 mm. in total length. All are typical with 18 costal grooves.

Eurycea bislineata cirrigera (Green). Two-lined salamander.

Six specimens were taken: five (2, WMC; 5193–95) from Little Contentnea Creek, ten miles west of Greenville, Pitt County, on September 4, and one (5196) from Chicod Creek, Grimesland, Pitt County, on September 5.

All specimens were found under logs or dead leaves on moist slopes above cypress swamps. The two following species and *Plethodon g. glutinosus* also occupied this habitat.

Eurycea longicauda guttolineata (Holbrook). Long-tailed salamander.

A single specimen of this species (WMC) was collected September 4, ten miles west of Greenville, Pitt County. The species is apparently not common here, as no other specimens were seen.

Manculus quadridigitatus (Holbrook). Dwarf salamander.

Three specimens (WMC; 5197–98) were found September 4 in the same locality and habitat as for the preceding species. These are the first specimens reported from Pitt County, and represent a slight northward extension of the known range of *M. quadridigitatus* in the immediate coastal area. The four other North

Carolina localities for the species are Raleigh, Wake County, Kinston, Lenoir County, Magnolia, Duplin County (Brimley, 1939), and Lake Waccamaw, Columbus County (Mittleman, 1947).

We have elected to retain the binomial for this species in the present account, since a recent paper (Neill, 1949) has reported much confusing variation in the characters used by Mittleman (*op. cit.*) in his diagnosis of three proposed subspecies. Neill found specimens from the upper coastal plain of Georgia and South Carolina impossible to allocate subspecifically.

Our three specimens present the following characters: Total length (mm.), 55, 47, and 48; number of costal grooves, 16, 15, and 15; number of costal grooves between adpressed toes, 3, 2, and 2; combined count of vomerine teeth, 11, 10, and 9. On the basis of these characters the specimens would be referable to *M. q. quadridigitatus*, as defined by Mittleman. This is to be expected from his distribution map.

SALIENTIA

Scaphiopus holbrookii holbrookii (Harlan). Spadefoot toad.

A single DOR specimen (not saved) was found August 7 on the road leading into the Duke Marine Laboratory, Pivers Island, Carteret County.

Bufo woodhousii fowleri (Hinkley). Fowler's toad.

Five specimens were collected: four from Carteret County, Shackleford Banks, August 14 (5200), August 20 (5201), and August 30 (5202); Cape Lookout, Core Bank, August 18 (5203); and one from Pitt County, ten miles west of Greenville, August 28 (5199).

Specimens from Shackleford and Core Banks were taken on the "sound" side of the banks among small dunes grown to sea oats (*Uniola*), and under beach drift at high tide mark. Brimley (1940) calls *B. w. fowleri* the common North Carolina toad. Engels (1942, p. 293) found the species to be common on Ocracoke Island, and the only amphibian represented there; and Brandt (1936) reported it to be abundant and generally distributed in Beaufort County.

In view of these reports it is difficult to understand the range map given by Wright and Wright (1949, map 14, p. 207) which appears to exclude *B. w. fowleri* from nearly all of the North Carolina coastal plain.

Acris gryllus gryllus (Le Conte). Cricket frog.

Cricket frogs are common along lowland streams and around small ponds in pine woods. Three specimens were collected: two from ten miles west of Greenville, Pitt County, on July 16 (WMC), and on August 28 (5205); and one (5206) from two miles south of Newport, Carteret County, on August 16.

Brimley (1940) distinguishes *A. gryllus* and *A. crepitans* in North Carolina, the former largely restricted to the coastal plain. Our specimens agree with his description of North Carolina *gryllus*. Number 5206, a recently metamorphosed specimen in which the tail is still present, clearly shows the diagnostic characters (two post-femoral dark stripes, absence of anal warts) used by Netting and Goin (1945) in separating *A. g. dorsalis* of peninsular Florida.

Hyla squirella Latreille. Southern tree frog.

Two specimens of this species are in the collection. One (5207) collected on Shackleford Banks, Carteret County, August 20; the other (WMC) from Pitt County, July 15.

The species is not previously on record for Pitt County, but is recorded from many coastal counties, and from the "banks" at Cape Hatteras, Dare County (Brimley, 1940). Engels (1942) mentions its possible former occurrence on Ocracoke Island. The Shackleford specimen was found on a tree trunk in a yaupon-prickly ash-juniper thicket several hundred yards southeast of Mullet Pond.

Rana catesbeiana Shaw. Bull frog.

Two specimens of this abundant species were taken in Pitt County: one (WMC) from Little Contentnea Creek, ten miles west of Greenville, on July 5; and one (5208) in a cypress swamp near Grimesland, September 5.

Rana clamitans Latreille. Green frog.

The species is common along upland streams in Pitt County. Nine specimens were taken, all from a small branch of Little Contentnea Creek, ten miles west of Greenville, Pitt County: eight (WMC) July 15, and one (5209) August 28.

Rana palustris LeConte. Pickerel frog.

Two specimens from Little Contentnea Creek, ten miles west of Greenville, Pitt County: one (WMC) July 15, and one (5210) August 28, represent the first county records. They were taken along a small upland stream in a marshy pasture. Both show extensive dark mottling on the venter.

R. palustris seems much less common than either *R. clamitans* or *R. pipiens sphenocephala* in the coastal region of North Carolina.

Rana pipiens sphenocephala (Cope). Southern leopard frog.

The species is represented in our collection by 15 specimens from the following localities: Little Contentnea Creek, ten miles west of Greenville, Pitt County, ten specimens (9, WMC), July 15, and one (5211) August 28; Chicod Creek, near Grimesland, Pitt County, three specimens (WMC; 5212–13), September 5; near Newport, Carteret County, one specimen (5214), August 28; and Mullet Pond, Shackleford Banks, Carteret County, one specimen (5215), August 20.

Leopard frogs were the most abundant anurans at all collecting sites, being equally common along swampy pasture streams in Pitt County, around sink holes in pine flatwoods near the coast, and in the cattail marsh at Mullet Pond (fresh to slightly brackish water).

Although Brimley (1940) gives records for nearly all coastal counties our specimens are apparently the first from Pitt County.

Occurrence of frogs on the outer banks is limited by the presence of permanent fresh water ponds. Published records exist for Cape Hatteras, Dare County, and Coues (1871) mentions the occurrence of two species of *Rana* on Shackleford

Banks. These are not identified, but it seems likely that one of those referred to was *R. p. sphenocephala*. A later report (Coues and Yarrow, 1878) lists no ranid except a puzzling record of the wood frog (under the name *Rana temporaria sylvatica*).

Our specimens from all localities agree in possessing such suggested characters of *R. p. sphenocephala* as a white dot in the center of the tympanum, relatively long, pointed snouts, and few dorsal dark spots, which are often sub-quadrate and usually without light edging.

Microhyla carolinensis (Holbrook). Narrow-mouthed toad.

Two specimens (WMC; 5216) were taken on Shackleford Banks, Carteret County, August 21. Both were found under small decaying logs in open live oak woods. They showed a bright-brick red dorsal coloration in life which has disappeared in preservative. Another specimen was collected by the junior author at the Greenville airport, Pitt County, in June 1949.

The species has apparently not been previously noted from either Carteret or Pitt counties.

SAURIA

Anolis carolinensis Voigt. Anole.

The three specimens collected are all from Carteret County: two (WMC; 5219) from Shackleford Banks, August 21, and one (5218) from near Beaufort, August 26. Shackleford specimens were taken in a dense bay-yaupon thicket. Anoles were common about the town of Beaufort, and several were seen on Piver's Island.

Cnemidophorus sexlineatus (Linné). Sand swift.

Seven specimens are in the collection: three (3, WMC) from Greene County, July 12, and four (WMC; 5220–22) from Cape Lookout, Core Bank, Carteret County, August 18.

Sand swifts were common under beach drift at Cape Lookout along with *Bufo w. fowleri*. The species apparently occurs commonly on all the North Carolina coastal banks, since Engels (1942) reports it "very common" in similar habitats on Ocracoke Island, and numerous examples were seen on Shackleford Banks.

From our observations *Cnemidophorus* appears to be much less common on the coastal mainland. In the Pitt-Greene County area it has a spotty distribution, colonies being found in isolated sandy areas. The species was observed at two localities, both former sand pits, on the bank of Little Contentnea Creek, located about three miles apart. From the southernmost of these, in Greene County, specimens representing the first records for the county were taken. At the other sand area, in Pitt County, several individuals were seen but eluded capture. Brief visits by the junior author disclosed no *Cnemidophorus* in the extensive sand area on the north bank of the Tar River west of Greenville, Pitt County.

Leiolopisma laterale (Say). Ground skink.

A single specimen (WMC) was taken in Pitt County, July 20.

Eumeces inexpectatus Taylor. Floridan five-lined skink.

One specimen (5217) taken near Newport, Carteret County, August 6, proves to be of this species. It was found under the bark of a charred log in open pine woods.

A number of specimens of *E. inexpectatus* are known from the coastal area of North Carolina, including one from New Bern, Craven County, examined by Taylor in describing the species (Taylor, 1932).

Eumeces fasciatus (Linné) Blue-tailed skink.

A single example (WMC) was collected July 12 in Beaver Dam Swamp, one mile east of Bellarthur, Pitt County.

SERPENTES

Farancia abacura abacura (Holbrook). Mud snake.

The single specimen (WMC), a male 1380 mm. in total length, was taken by the junior author from a drainage ditch in a large pine woods area in Pitt County. It is the first recorded for the county.

Rhadinaea flavilata (Cope). Yellow-lipped snake.

One specimen (5223) was secured August 21, two miles southeast of the northwest end of Shackleford Banks, which thus becomes the third reported locality for the species in North Carolina. It is of interest that two of the three known North Carolina specimens are from the offshore banks. The type was collected on Bogue Bank by Yarrow in November, 1871, "... some eight miles south [?] of Ft. Macon" (Coues and Yarrow, 1878). The present locality is some twelve miles east by slightly south of the type locality, assuming that Yarrow meant eight miles west or southwest of Ft. Macon. Since the trend of Bogue Bank is generally east-west and its width hardly anywhere exceeds a mile, eight miles *south* of Ft. Macon is an improbable locality. The other specimen for the state is from Councils, Bladen County (Schmidt, 1916).

In view of the reported usual association of the species with moist or marshy habitats it may be well to record that this specimen was found under scanty leaf litter in a quite xeric, open, live-oak woods only a few yards from the foot of a moving dune. No shrub or herb growth was present, and there was no marshy ground within several hundred yards. *Microhyla carolinensis* and *Anolis carolinensis*, both mentioned as possible prey-species of *R. flavilata*, were taken in the immediate vicinity.

In color and scutellation our specimen agrees in detail with the description given by Malnate (1939), except that the labials are more densely flecked with brown. The indistinct median dorsal stripe he mentions is evident on the anterior half of the body.

The specimen is a female 263 mm. in total length with a tail length of 83 mm. It has 127 ventrals and 68 caudals. The infralabials are 9-9; the supralabials 7-7.

Coluber constrictor constrictor (Linné). Black snake.

A single example (WMC) was secured in Pitt County, July 10. In addition cast skins of this species were found on Shackleford Banks, August 21; and two DOR's were seen near Cherry Point, Craven County, September 3.

Elaphe obsoleta obsoleta Say. Pilot black snake.

This species is represented in the collection by one specimen (WMC), a female 1703 mm. in total length taken ten miles west of Greenville, Pitt County, on August 6. It is uniformly dark above with no evidence of a blotched or striped pattern. Mid-body scale rows number 27.

We refer the present specimen to *E. o. obsoleta*, since it shows no evidence of variation toward the pattern of *E. o. quadrivittata*. The junior author has found black chicken snakes to be conspicuous and common in the Pitt County area, but has never observed the striped form there. Brimley (1941) records *E. o. obsoleta* as absent south of Wake and Bertie counties, and (1942) reports *E. o. quadrivittata* from Pitt and adjacent Beaufort counties, these localities marking the northern limit of its recorded range. Brimley (*ibid.*) also records apparent *obsoleta-quadrivittata* intergrades from Wake, Johnston, and Cumberland counties in the upper North Carolina coastal plain. Neill (1949a) in his discussion of the *Elaphe obsoleta* group mentions another such intergradient specimen from Columbus County in extreme southeastern North Carolina. He also considers the specimen from Shackleford Banks, Carteret County, which afforded the basis for *E. quadrivittata parallela* (Barbour and Engels, 1942) to be an *obsoleta-quadrivittata* intergrade. From these records it seems rather evident that the populations of *Elaphe obsoleta* occupying the North Carolina coastal plain south from Wake and Pitt counties are a genetically mixed assemblage in which individuals of typical *quadrivittata* pattern occur along with those bearing patterns which tend more or less strongly toward that of *obsoleta*. In the Pitt County area, and presumably all of the coastal plain north of this, the *obsoleta* pattern is found almost exclusively. Specimens from more localities are needed before the area of intergradation can be accurately located and the nature of the cline from *E. o. obsoleta* to *E. o. quadrivittata* discerned.

Lampropeltis calligaster rhombomaculata (Holbrook). Mole snake.

Two specimens (WMC; 5179) were collected west of Greenville, Pitt County, on August 10. Both were taken along country roads bordering upland pine woods. The junior author saw several additional specimens which were plowed up in fields near Greenville, April 1949. The species is not previously reported from Pitt County, but it is probably of frequent occurrence in the coastal area, since Brimley's (1925) records show it to be fairly common at Raleigh.

The specimens fall well within the range outlined by Blanchard (1921) in all characters of pattern and scalation. No. 5179, a male, 855 mm. in total length,

is somewhat unusual in showing complete retention of a well-defined pattern in a large adult. The dorsal body pattern itself is typical, consisting of 40 (snout-vent) convex, bright reddish-brown blotches on a light brown ground color.

We have here given *rhombomaculata* subspecific rank under *Lampropeltis calligaster* in accord with evidence of intergradation of *calligaster* and *rhombomaculata* in northeastern Mississippi, presented by Cook (1945). It should be noted that Blanchard fully anticipated this intergradation in his discussion of the affinities of *rhombomaculata* (*op. cit.*, pp. 131–134).

Lampropeltis getulus getulus (Linné). Common king snake.

The single specimen in the collection (WMC) was taken in Pitt County, August 2. The junior author has found the species to be common in this area.

Natrix erythrogaster erythrogaster (Forster). Red-bellied water snake.

This species is represented by one specimen (WMC) taken from a small spring-fed stream near the Tar River, ten miles northwest of Greenville, Pitt County, July 14. The species appears to be restricted to the coastal plain in North Carolina. Brimley (1942) gives no records from west of Wake County, where it is rare. Our specimen, a male 515 mm. in total length, is the first from Pitt County. It shows a lateral series of obscure, squarish, dark markings, which must represent a partial retention of the juvenile pattern. The belly is without markings.

Natrix sipedon fasciata (Linné). Southern banded water snake.

Four specimens were taken from canals and swamp streams in the Neuse River drainage ten miles west of Greenville, Pitt County: one (WMC, a male with 131 ventrals) on July 10; two (5176, a female with 136 ventrals, and 5177, a female with 130 ventrals) on August 28; and one (WMC, a female with 136 ventrals) on June 5, 1949. They represent the first records for the county, but the species is abundant there in all aquatic habitats except the large rivers.

Brimley (1942) records *N. s. fasciata* from Bertie, Craven, and New Hanover counties on the coast, but expresses doubt concerning the extent of the range of this form in eastern North Carolina. This, coupled with the fact that published range maps for the subspecies of *Natrix sipedon* (Schmidt and Davis, 1941, p. 221) show our Pitt County locality to be near the region where the ranges of *N. s. sipedon* and *N. s. fasciata* meet, makes it advisable to describe the color and pattern of the specimens in detail.

The dorsal pattern of all our specimens consists of transverse bands. One of the specimens (WMC, July 10, 1948) is so dark that the pattern cannot be satisfactorily studied. On two other specimens (5177; WMC, June 5, 1949), also dark, the bands number 28 and 31 respectively. No. 5176 was shedding at the time of capture, and shows the dorsal pattern and color distinctly. The dorsal ground color is light grey, becoming paler on the lower three or four dorsal scale rows. The pattern consists of 32 crossbands which are black dorsally, and orange-red broadly edged with black on the sides. The bands are continued onto

the lateral quarter of the ventrals, and are evident (in 5176) to the tip of the tail. Dorsally the bands are much expanded into quadrate or rhombic blotches four or five scale lengths wide at middorsum, and separated by less than one scale length or in some cases are confluent. Laterally the bands are much narrower, averaging two scale lengths wide, with interspaces of three scale lengths.

The ventral ground color in all specimens is light yellow, becoming grey on the subcaudals. The markings on the ventrals, other than the continuations of the crossbands, are black, or red margined with black. They are predominantly rectangular, especially on the caudals and posterior ventrals. Anteriorly the blotches tend to become irregular in shape, and are occasionally semilunar (as in *N. s. sipedon* and *N. s. pleuralis*). Many of the ventral plates on all specimens show narrow black anterior margins.

The character combination of the dorsal body pattern of complete transverse bands, predominantly squarish ventral markings, and 130 or more ventral plates is diagnostic of *N. s. fasciata* as defined by Clay (1938). The Neuse River drainage in the Pitt County area, therefore, appears to be occupied by populations of the common water snake, which are entirely typical of *N. s. fasciata* with no evidence of variation toward the characters of *N. s. sipedon*.

Natrix sipedon engelsi Barbour. Engels' water snake.

A single specimen of water snake (Duke University Museum), a female 830 mm. in total length, was collected by the junior author June 19, 1949, at Mullet Pond, Shackleford Banks, Carteret County. This is the type locality of the subspecies described by Barbour (1943) under the above name. Barbour's description, drawn from a single specimen, is brief, not adequately differentiating *N. s. engelsi* from other races of *Natrix sipedon*, and no further references to this subspecies have appeared. In the most recent complete treatment of United States snakes (Perkins, 1949) *N. s. engelsi* is not recognized.

Collection of the present topotypic specimen prompted us to attempt a clarification of the nature and status of the variation to which the name *N. s. engelsi* had been applied. The specimen was compared in pertinent characters of pattern and scutellation with our series of *N. s. fasciata* from the Pitt County area of the coastal plain, and with Clay's (1938) accounts of *N. s. fasciata* and *N. s. sipedon*, the forms geographically nearest the presumed range of *N. s. engelsi*. In addition, Mr. Arthur Loveridge of the Museum of Comparative Zoology, Harvard, has kindly checked the characteristics of the type specimen (MCZ 46688), and through the courtesy of Dr. W. L. Engels we have been permitted to examine three water snakes from his collection (W. L. Engels 944, 1085, and 1086) taken on Core Bank, Carteret County, and Ocracoke Island, Hyde County. The included table, and following brief descriptions of patterns summarize the data acquired.

Natrix s. engelsi—Dorsal pattern usually obscure, the black dorsal areas confluent or with narrow (less than one scale length wide) light interspaces. Arrangement of dorsal and lateral blotches various: of complete transverse bands throughout (Shackleford Banks); or with four to nine complete transverse bands

anteriorly, posterior to which the dorsal and lateral series of blotches alternate (Core Bank and Ocracoke Island). Lateral blotches two to three times as wide as the interspaces separating them. Posterior two-thirds to one-half of ventral plates almost entirely black with small irregular light blotches. Anterior ventrals lighter with irregularly arranged sub-quadrate red-centered dark markings.

TABLE 1

SPECIMEN	SEX	LOCALITY	NUMBER OF VENTRALS	NUMBER OF LATERAL BARS (SNOUT-VENT)
		Natrix sipedon engelsi		
MCZ-46688	♂	Mullet Pond, Shackleford Banks, Carteret Co., N. C.	133	35
Duke Univ. Museum	♀	Mullet Pond, Shackleford Banks, Carteret Co., N. C.	138	36
WLE-994	♀	Cape Lookout, Core Bank, Carteret Co., N. C.	144	37
WLE-1085	♂	Ocracoke Island, Hyde Co., N. C.	142	39
WLE-1086	♂	Ocracoke Island, Hyde Co., N. C.	141	32
		Average....................	139	36
		Natrix sipedon sipedon		
		Ranges and averages given by Clay (1938)	135–155	Usually more than 30
		Natrix sipedon fasciata		
		Ranges and averages given by Clay (1938)	126–137	19–33 Ave. 24
5176	♀	10 miles west of Greenville, Pitt Co., N. C.	136	32
5177	♀	10 miles west of Greenville, Pitt Co., N. C.	130	28
WMC-July 10, 1948.	♂	10 miles west of Greenville, Pitt Co., N. C.	131	—
WMC-June 5, 1949.	♀	10 miles west of Greenville, Pitt Co., N. C.	136	31
		Average.....	133	30

Natrix s. sipedon—Three to ten anterior transverse bands, posterior to which the dorsal and lateral series of dark blotches alternate. Lateral blotches equal to or slightly wider than the interspaces separating them. Ventral pattern of crescentic red or dark markings, darker posteriorly.

Natrix s. fasciata—Dorsal and lateral pattern of transverse dark bands throughout. Bands laterally equal to or slightly narrower than the interspaces separating them. Ventral pattern of scattered sub-quadrate red or red-centered dark markings.

The above data show that in characteristics of dorsal pattern and in number of ventral plates specimens of water snakes from the North Carolina offshore

banks exhibit an intermediate condition such as might be expected of samples from a series of intergradient populations between *N. s. sipedon* and *N. s. fasciata*. Specimens from Shackleford Banks have a banded pattern and ventral counts within the range for *N. s. fasciata*, whereas those from Core Bank and Ocracoke Island have a dorsal pattern arrangement similar to that of *N. s. sipedon* and the higher ventral counts of that subspecies. However, in conjunction with the above apparently intergrading characters the "banks" water snakes possess other constant characters in which they differ from both *N. s. sipedon* and *N. s. fasciata*. They are immediately distinguishable from most specimens of both the above subspecies by their general blackish appearance. All specimens seen differ diagnostically in the following characters: 1) venter very heavily pigmented, posterior one-half to two-thirds of ventral plates almost entirely black with small scattered light blotches; and 2) lateral blotches two to three times as wide as the interspaces separating them, the interspaces often less than one scale length in width.

It seems that this puzzling problem is best resolved by considering the populations of the common water snake which occupy the North Carolina offshore banks to represent a distinct dark subspecies, to which the name *Natrix sipedon engelsi* Barbour should be applied. We regard this decision as tentative. Final solution of the problem must await the collection of adequate samples of water snakes from a number of localities both on the "banks" and the coastal mainland. At present we consider it most likely that *N. s. engelsi* will be found to represent another brackish water specialization of the species *Natrix sipedon*, which has already been proved prolific in the development of races adapted to inhabit brackish water environments. *N. s. clarkii* occupies such habitats along the Gulf of Mexico from the central Texas coast to west Florida, and *N. s compressicauda* occurs along the coasts of peninsular Florida and has in addition extended its range to the northern coast of Cuba.

It seems likely that *N. s. engelsi* will be found to intergrade with *N. s. sipedon* northward along the offshore banks. Intergradation with *N. s. fasciata* is to be expected along the inland limits of salt marsh-brackish water habitats. Although conjecture in the present absence of information is rather fruitless, it is possible that the range of *N. s. engelsi* may also involve a narrow coastal strip along the Atlantic south from Shackleford Banks.

Natrix taxispilota (Holbrook). Brown water snake.

A single specimen (WMC) was collected along the south bank of the Tar River, ten miles northwest of Greenville, Pitt County, on July 14.

The species is apparently restricted to swamps along the larger streams, and is rather common in such situations. It is reported by Brimley (1942) from eight counties in the coastal plain, but not previously from Pitt County.

The specimen, a male, is entirely typical, having 30 scale rows at mid-body, supralabials 10-10, and infralabials 12-12. The dorsal pattern consists of 27 square dark blotches (snout-vent), with a similar alternating series on each side.

Storeria occipitomaculata occipitomaculata (Storer). Red-bellied snake.

One specimen (WMC) found ten miles west of Greenville, Pitt County, July 15, is the first on record for the county. It was found under a wood pile several hundred yards from the edge of a tract of pine forest.

Thamnophis sirtalis sirtalis (Linné) Klauber. Ribbon snake.

One specimen (WMC) was collected ten miles west of Greenville, Pitt County, August 6. It represents a "first record" for the county, although the junior author has found the species to be common except in excessively dry years.

The above citation of authority follows the suggestion of Smith (1950). It appears to offer the simplest means of avoiding confusion in the use of the name *T. sirtalis* in reference to the ribbon snake, which is necessitated by Klauber's (1948) demonstration that the Linnean name *T. sirtalis* has previously been misapplied to the common garter snake (now *T. ordinatus*).

Thamnophis ordinatus ordinatus (Linné). Common garter snake.

Our only specimen (WMC) was taken in Pitt County on July 15. It is a female, 648 mm. in total length, which shows an unusual aberration of the color pattern. The characteristic dorsal and lateral stripes of the species are absent, and are replaced by a pattern of numerous sub-rectangular black spots (usually involving parts of three or four scales) on a dark brown ground color. The spots exhibit no regular arrangement. The pattern of the venter is normal.

Agkistrodon contortrix mokeson (Daudin). Northern copperhead.

Two specimens (WMC; 5178) were taken July 7, ten miles west of Greenville, Pitt County. They were found close together at the edge of a cypress swamp adjoining open fields. Copperheads appear to be common in the vicinity, since many others were reported during our collecting.

Gloyd and Conant (1943) refer copperheads from eastern North Carolina to *austrinus* (= *contortrix*), extending the range of this form up the coast to southeastern Maryland. They mention, however, (*op. cit.*, p. 156) the need for examination of additional material from the North Carolina coastal area. The principal diagnostic character used to separate *contortrix* and *mokeson* is the amount of constriction of the cross bands at the dorsal mid-line. In *contortrix* the bands are narrower, averaging less than three scale lengths wide, and many of them incomplete, whereas *mokeson* has fewer incomplete bands with the complete bands averaging over three scale lengths in width. In order better to allocate our specimens, their band characteristics were compared with specimens of *mokeson* from western Maryland, and western Virginia; and with *contortrix* from eastern Texas. The results are presented in table 2.

These data indicate that the Pitt County specimens are practically identical with more northern *mokeson* in the diagnostic character of band width. For this reason we have referred our specimens to *mokeson* despite the fact that they fall within the geographic range of *contortrix* as stated by Gloyd and Conant.

Due to the fact that McCauley (1945) has reported the presence of copperheads resembling *contortrix* in southeastern Maryland, it seems probable that we are here dealing with intergrading populations which occupy a broad zone in the coastal plain of southeastern Maryland, Virginia, and North Carolina.

Agkistrodon piscivorus piscivorus (Lacépède). Water moccasin.

One specimen (WMC) was collected two miles northwest of Grimesland, Pitt County, September 5, in a cypress swamp along Chicod Creek. It is a large dark male measuring 1275 mm. in total length, and is the first reported from the county.

Although this was the only specimen encountered, the species is well-known locally by the name "water rattler." It is said to be abundant in the swamps, and reportedly also occurs along smaller streams into the uplands.

TABLE 2

LOCALITY	SPECIMEN NUMBER	NUMBER OF COMPLETE BANDS	NUMBER OF INCOMPLETE BANDS	AVERAGE BAND WIDTH IN DORSAL MID-LINE*
Pitt Co., North Carolina	WMC	13	2	3.2
Pitt Co., North Carolina	5178	11	1	3.3
Alleghany Co., Virginia	WMC	15	1	3.2
Frederick Co., Maryland	2935	15	2	3.2
Hardin Co., Texas	1204	12	1	1.8

* In calculating average band widths the total number of scale widths of all bands combined was divided by total number of bands (snout-vent), including incomplete bands.

Sistrurus miliarius miliarius (Linné). Ground rattlesnake.

The single specimen (Duke University Museum) was collected by the junior author one mile east of Leechville, Hyde County, October 17. It is a female 314 mm. in total length.

Crotalus horridus atricaudatus Latreille. Canebrake rattlesnake.

The present specimen (WMC), representing the first Pitt County record, was collected by the junior author July 4, 1949, on a road through a large tract of pine forest. It is a female 1235 mm. in total length with 178 ventrals, 22 caudals, and 23 scale rows at midbody. The rattles are unusually intact for a wild-caught specimen, the string numbering 13 rattles and measuring 75 mm. in length.

The specimen is referred to *C. h. atricaudatus* despite its having only 23 dorsal scale rows because the color pattern is entirely characteristic of that form: anterior lateral blotches with light centers; distinct postocular dark stripe; and red brown mid-dorsal stripe distinct for the entire length of the body.

TESTUDINATA

Kinosternon subrubrum subrubrum (Lacépède). Common mud turtle.

Two specimens are at hand: one (WMC) collected at Little Contentnea Creek, ten miles west of Greenville, July 9; the other (5172) from Chicod Creek Swamp

near Grimesland, Pitt County, September 5. These are the first recorded from Pitt County. The first of these is typical *K. s. subrubrum*. No. 5172, a female with a carapace length of 117 mm., clearly shows the light striping on the sides of the head, which elsewhere characterizes *K. s. hippocrepis*. Another similarly marked specimen from the same locality has since been lost. Comparison of 5172 with 15 specimens of *K. s. hippocrepis* in UINHM from Louisiana, Arkansas, eastern Texas, and southeastern Oklahoma shows no difference in the head striping, except that some of the western specimens (all considerably smaller, the largest with carapace 95 mm. in length) have the stripes slightly broader, and more clearly defined.

The stated range of *K. s. hippocrepis* extends eastward only to southern Alabama, and intergradation with *K. s. subrubrum* presumably occurs on the Gulf coastal plain in southern Mississippi and Alabama, and perhaps extreme western Florida (Carr, 1940, p. 98). Due to the wide separation between these points and the North Carolina locality it seems requisite to consider the specimens mentioned as representing a local color pattern anomaly of *K. s. subrubrum*, at least until the occurrence of this variation becomes more fully known.

Chelydra serpentina serpentina Linné. Common snapping turtle.

The snapping turtle was found to be common in all streams in the Pitt County area where any collecting was done. Two specimens taken July 7 from Little Contentnea Creek were later discarded.

Clemmys guttata (Schneider). Spotted turtle.

Our single specimen (WMC) was collected from Little Contentnea Creek, ten miles west of Greenville, Pitt County, June 19.

Terrapene carolina carolina (Linné). Box turtle.

Three specimens were collected ten miles west of Greenville, Pitt County: two (WMC) on July 1, and one (5175) on September 4. The species was found to be common in upland habitats in Pitt County, particularly in overgrown fields. Another specimen (subsequently lost) was collected in pine woods five miles north of Beaufort, Carteret County, on August 7.

Malaclemys terrapin centrata (Latreille). Diamond back terrapin.

One specimen (5173) was taken July 28 from the trawl of a shrimp boat in the Newport River, above Beaufort, Carteret County. It is listed under the present subspecies solely on the basis of range, as the subspecific characters are not strongly shown.

Chrysemys picta picta (Schneider). Painted turtle.

Two specimens were collected in cypress-gum swamps in Pitt County: one (5174) along Chicod Creek, two miles northwest of Grimesland, September 5; and the other (WMC) from Little Contentnea Creek, ten miles west of Greenville on July 11. They are the first recorded for the county.

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A NEW SPECIES OF DIAPTOMID COPEPOD FROM MANITOBA*

By I. Gilbert Arnason

Central Fisheries Research Station, Fisheries Research Board of Canada

Winnipeg, Manitoba

Twenty-three Text Figures

Diaptomus manitobensis n. sp.

Large stout species. Female 2.4 mm. exclusive of furcal setae, male 2.6 mm. Metasome plump with first segment longer than three following, strongly convex in dorsal profile especially in mid region and at anterior end; posterolateral projections fairly large reaching to spines of genital segment; projections directed obliquely posteriorly and laterally each tapering to sharp hyaline points tipped by tiny spines; a second larger point and spine on dorsal margin.

First segment of female abdomen longer than rest of abdomen; much dilated in front and somewhat laterally with two small lateral spines. Second segment very short. Furca about the same length as the second segment. Furcal rami ciliate on inner margins of distal third.

Antennae 25-segmented, slender and relatively long, reaching to middle of abdomen. Small setae unmodified (Fig. 3); three setae on segment 2 and segment 16, two each on segments 6, 9–11, 13–15, 17, 18, 22–24, one each on all others save segment 25 which has five. Major spines on segments 10, 11, and 13 of right antenna of male (Fig. 3); major spines slightly to considerably incurved; spine of segment 10 about the same length as width of antenna, that of segment 11 slightly longer, and that on segment 13 at least twice as long as that on segment 10, incurved and bluntly hornlike in appearance. Segments 13–17 of male right antenna markedly swollen, segment 18 somewhat less so; lateral hyaline membrane on antepenultimate segment slender and terminating in a short delicate incurved hook.

Fifth legs of male narrow, elongated; left leg reaching just past middle of first segment of exopodite of right leg. Spines of basal segments of male fifth feet short, stout and blunt. Second basal segment of right foot quadrangular, about two and one-half times as long as wide; near the proximal end a dome-shaped hyaline projection confluent with a lateral hyaline lamella extending most of its length along the inner surface and terminating distally in a broad hyaline hook-shaped process. The first segment of exopodite of right leg about four-fifths as wide and about two-thirds as long as the second basal segment. Second segment of exopodite slender, widening somewhat about seven-eighths from the proximal end, and then narrowing sharply in the distal eighth; about one and one-half times as long as the first exopodite or about the same length as the second basal segment (basipodite). Lateral spine, narrow and straight, about

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one-third longer than segment is wide, arising from distal lateral angle, continuing almost in line with lateral margin of segment; claw (Fig. 2) over two-thirds as long as second segment of exopodite, slender, smooth, somewhat swollen in proximal portion, curved symmetrically inward in the middle region and outward at the pointed tip. The endopodite slender, one-segmented, extending about seven-eighths of the length of the first segment of the exopodite, coarsely setose at the distal end. Second basal segment of left leg quadrangular, one and one-half times as broad as first segment of exopodite, with a narrow hyaline ridge running the length of the inner lateral margin; lateral spine short and stout, inserted slightly anterior to distal angle. First segment of exopodite about twice as long as broad, widening distally, its outer margin almost straight, its inner margin curved; inner margin terminating in a rounded or dome-shaped projection which is finely setose. Second segment of exopodite slender, about four times as long as wide, terminating in two spines, the outer of which is short and smooth and the inner of which is long curved and setose. Endopodite one-segmented, slender, extending slightly beyond the distal end of the first exopodite, crenulated along the inner margin and setose at the tip.

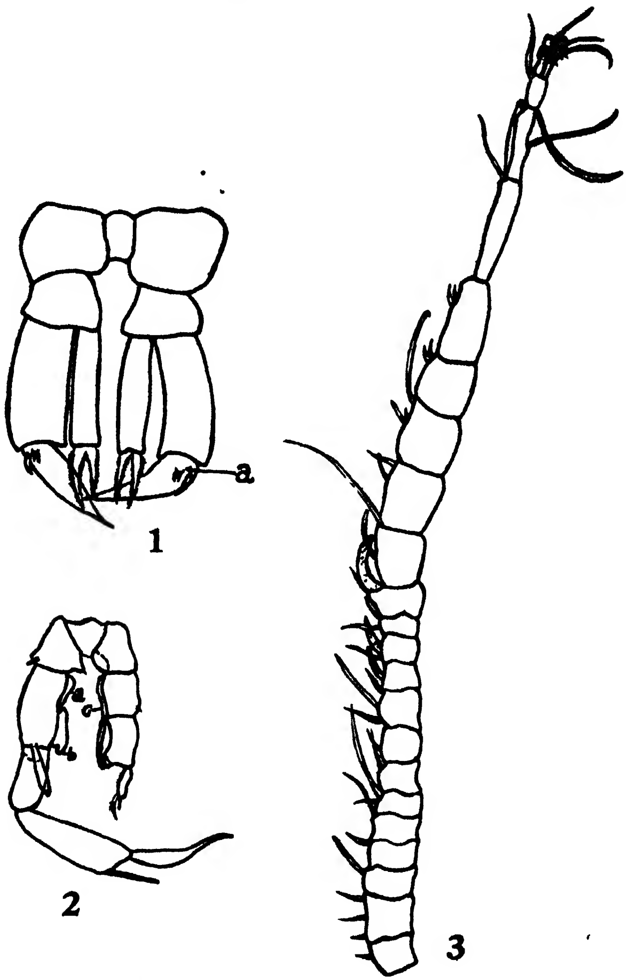
Fifth legs of female (Fig. 1) is relatively long and stout; third segment of exopodite rudimentary, indistinct, its spine nearly as long as its seta; spine on second segment stout, incurved, about twice as long as seta of third segment. Second segment with claw about the same length as inner margin of first segment; claw relatively slender, somewhat curved, finely denticulate on both inner and outer margins, but somewhat less so on outer margin. Endopodite one-segmented, slender, reaching nearly to end of first segment of exopodite; apical portion of endopodites truncated, bearing two long apical setae, the median slightly over four-fifths as long as the lateral, and with proximal spinelets graduating into distal hairs.

TAXONOMIC POSITION

This species resembles *Diaptomus caducus* Light (1938) in size and in the large number of setae on the antennae, but differs from it slightly in the distribution of the setae. (*D. manitobensis* has three setae on segment 2 and segment 16, and one on segment 19, while *D. caducus* has four setae on segment 2, and two each on segments 16 and 19). The armature of the antepenultimate segment of the male right antenna, and the details of structure of the male and female fifth legs, distinguish this species both from *D. caducus* and from the closely related *Diaptomus shoshone* Forbes (1893).

In *D. caducus*, the process on the antepenultimate segment of the male right antenna is longer than the penultimate segment, thicker at the base and usually tapering to a point, rarely with a swollen tip (Fig. 17). In *D. shoshone*, the process on the antepenultimate segment is only slightly longer than the penultimate segment (Fig. 21), thicker at the base, tapering to a point. Both these species lack the lateral hyaline membrane found on the antepenultimate segment of *D. manitobensis*. In both *D. caducus* and *D. shoshone* there is a distinct third segment of the exopodite of the female fifth leg, while the corresponding third

segment of the exopodite in *D. manitobensis* is rudimentary and indistinctly separated from segment 2. In *D. manitobensis* the endopodite of the male fifth leg is one-segmented (in both right and left fifth legs), while in *D. caducus* it is



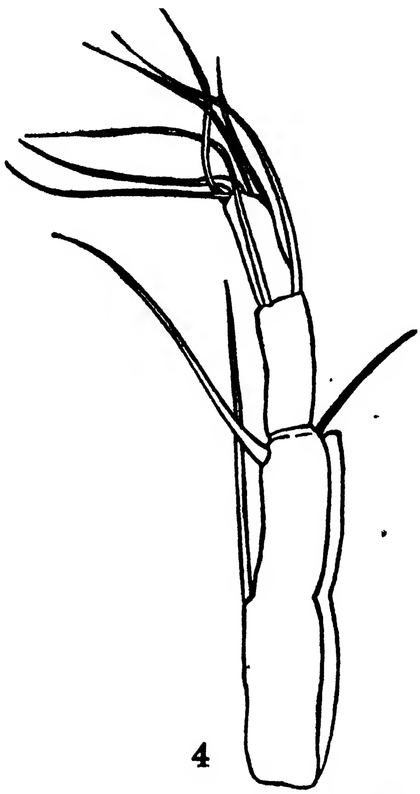
Diaptomus manitobensis n. sp. Fig. 1. Fifth legs of female (*a*, rudimentary third segment of exopodite). × 59. Fig. 2. Fifth legs of male (*a*, process; *b*, hook; *c*, process). × 57. Fig. 3. Right antenna of male. × 59.

two-segmented (Figs. 19, 20). In *D. shoshone* the endopodite of male left fifth leg is two-segmented, while the endopodite of male right fifth leg is one-segmented.

In *D. manitobensis* the absence of the slender apical extensions of the endopods of the fifth legs of the female is noteworthy. This character is a point of resemblance between this species and *Diaptomus leptopus* Forbes, *D. piscinae* Forbes and *D. caducus*, and also a point of distinction from *D. shoshone*.

D. manitobensis resembles *D. leptopus* and *D. piscinae* as well as *D. caducus* and *D. shoshone* in that the male right antenna appears to have only 22 segments instead of 25. This is due, in each case, to the fact that segments 19, 20, and 21 are ankylosed, as are also segments 22 and 23 (Fig. 3).

In *D. manitobensis* the end of the lateral hyaline lamella on segments 22 and 23 is projected distally into an incurved hyaline hook-shaped process (Fig. 3.). This characteristic distinguishes *D. manitobensis* from *D. piscinae*. It, moreover,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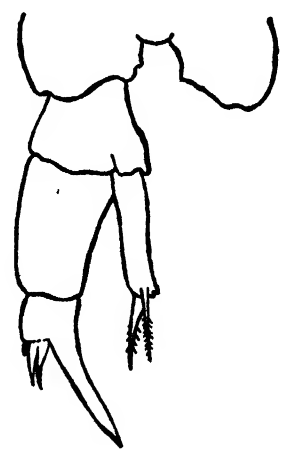
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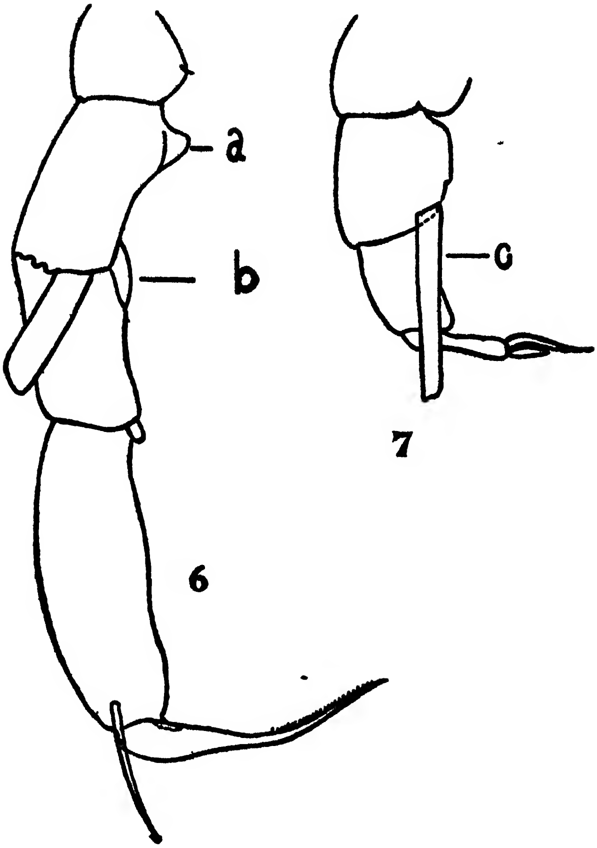
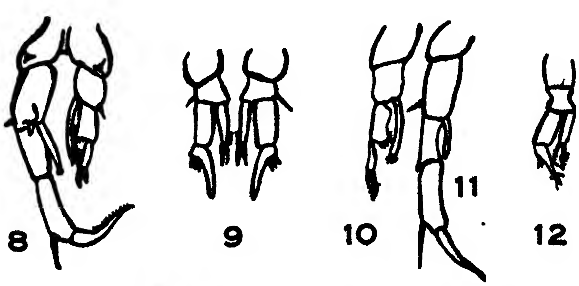
Diaptomus piscinae from Mt. Lake, Virginia. Fig. 4. Terminal segments of right antenna of male. Fig. 5. Fifth foot of female.

distinguishes it from *D. leptopus* according to "Marsh and several other copepod taxonomists" (1893), Herrick and Turner (1895), and Yeatman (correspondence with the author, 1949). Also the specimen of *D. leptopus* collected from Singush Lake, Manitoba, by the present author, lacks such a hook. Schacht (1897), however, in his description of *D. leptopus*, states that the segments 22 and 23 of the male right antenna have "... a narrow hyaline lamella produced into a hook which extends but a little beyond the end of the segment." Also S. A. Forbes (1882), in his original description of *D. leptopus* states: "The antennae reach to the tip of the furca, and the antepenultimate segment of the right antenna bears a small hook at the tip in the male." Forbes shows no antennal figure, and

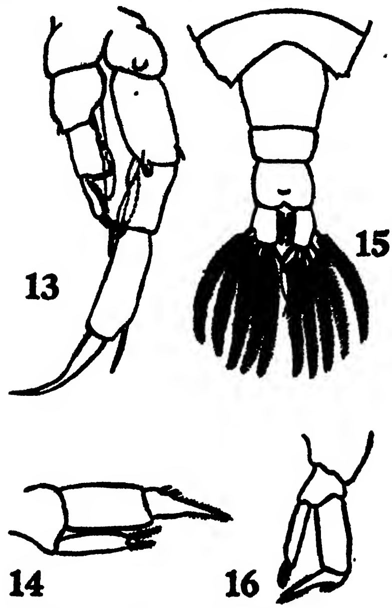


Diaptomus piscinae from Mt. Lake, Virginia. Fig. 6. Right fifth foot of male (*a*, process on second basal segment of right exopodite; *b*, hook on second basal segment long and large). Fig. 7. Left fifth foot of male, twisted around (*c*, endopodite very long).

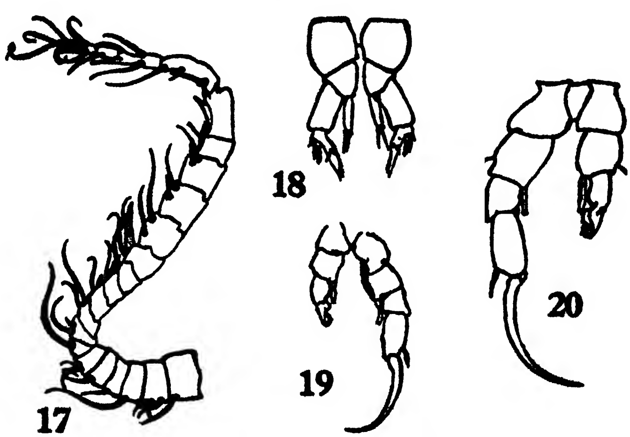


Diaptomus leptopus from Martha's Vineyard, Massachusetts. Fig. 8. Fifth legs of male. Fig. 9. Fifth legs of female. (Both after Wilson, 1932)

Diaptomus leptopus from Woods Hole, Massachusetts. Fig. 10. Left fifth leg of male. Fig. 11. Right fifth leg of male. Fig. 12. Left fifth leg of female. All × 44. (After Forbes, 1882)



Diaptomus piscinae. Fig. 13. Fifth feet of male. Fig. 14. Fifth foot of female, Portage Slough specimen. × 140. Fig. 15. Last thoracic segment and abdomen of female. × 70. Fig. 16. Fifth foot of female, Yellowstone Park specimen. × 140. (All after Schacht, 1897)



Diaptomus caducus. Fig. 17. Right antennule of male. × 34. Fig. 18. Fifth legs of female × 42. Fig. 19. Fifth legs of male in posterior view. × 34. Fig. 20. Fifth legs of male in anterior view. × 49. (All after Light, 1938)

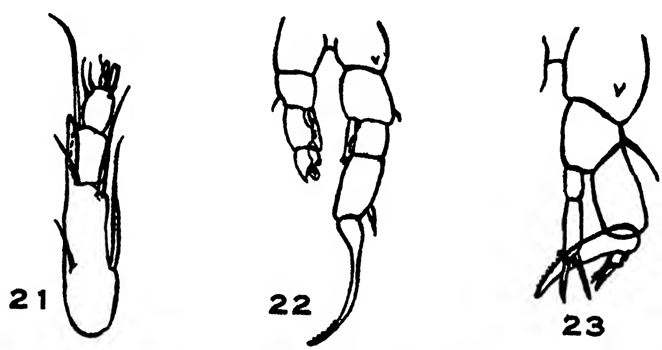
neither he nor Schacht says whether this hook is incurved or outcurved. Wilson (1932) states concerning the same character of *D. leptopus*: "Right antenna much swollen anterior to the geniculating segment; a narrow hyaline membrane on the antepenultimate segment, prolonged slightly at the distal end into a small *knob*."

It may be that Forbes and Schacht found specimens of *D. leptopus* with a small *knob*, such as Wilson finds on his specimens, at the distal end of the hyaline membrane of the male right antenna, and that this has been inaccurately described as a *hook*.

The following additional characters serve to distinguish *D. manitobensis* from *D. leptopus* Forbes and also from *D. piscinae* Forbes:

1. *The relatively short endopodite of the left fifth foot of the male* found in *D. manitobensis*. The endopodite of the left fifth foot of the male is only slightly longer than the first segment of the exopodite in *D. manitobensis*, while in *D. leptopus* the corresponding endopodite is considerably, and in *D. piscinae* greatly longer. In the latter species the length of the endopodite is equal to that of both first and second segments of the exopodite.

2. *Differences in the armature of the segments of the male right antenna.* The armature of the segments of the male right antenna of *D. manitobensis* has



Diaptomus shoshone. Fig. 21. Terminal segments of right antenna of male. × 120. Fig. 22. Fifth feet of male. × 72. Fig. 23. Fifth foot of female. × 72. (All after Marsh, 1907)

been noted in the description of this species. For purposes of comparison the armature of the segments of the male right antenna of *D. leptopus* is quoted from Schacht (1897): " . . . The first segment without armature, the other segments armed as follows: 2, with a short seta and a sense-club; 3, short seta and sense-club; 4 and 6, long spine; 5 and 7, long seta and sense-club; 8, long spine and very short spine; 9, long seta, long spine and sense-club; 10 and 11, process and long spine; 12, long spine, very short spine, and sense-club; 13, process, long spine and sense-club; 14, long seta, long spine, and sense-club; 15, process, short seta, long spine, and sense-club; 16, process, long spine, long seta, and sense-club; 17, process, and short thick spine; 18, process; 19, 20 and 21 (completely ankylosed), a narrow hyaline lamella produced into a hook which extends but little beyond the end of the segment, and two long setae; 24, two long setae; and 25, four long setae and a sense hair. Some of the setae on the last segment are sparsely hairy." It will be seen that *D. manitobensis* differs in some or all details of the armature of *every* segment of the male right antenna, *excepting only* the ankylosed segments 22 and 23, and segment 24. In these segments, only, is the armature identical.

I have not found a detailed description of the armature of all the segments of the male right antenna of *D. piscinae*. The following is quoted from Forbes (1893): "The right antenna of the male is without notable distinctive characters. The antepenultimate segment is as long as the two following taken together; the fourth from the tip bears two long sword-like spines at its margin, both attached to its basal fourth; the expanded segments are well armed with conical spines, straight and curved, but without hooks." Forbes also states: "... This species (*D. piscinae*) differs from *D. leptopus* by its more slender form and by the absence of the antennal hook." The fourth segment from the tip of the male right antenna of *D. manitobensis* bears only a single seta, at its distal end, whereas Forbes' specimens of *D. piscinae* bore two long sword-like spines at the margin, both attached to the basal fourth, on the corresponding segment of the male right antenna. In addition, Marsh, for *D. leptopus* (1907, Pl. XX, Fig. 5) and Carolyn Coker (Fig. 4) for *D. piscinae*, both show a slender hairlike seta at the distal end of the antepenultimate segment, and on the same side as the hyaline lamella. This is not found in *D. manitobensis*. Furthermore, Wilson (1932) shows an illustration (Pl. I, Fig. f.) of a female *D. leptopus* bearing extremely hairy setae. In the female of *D. manitobensis* only a few setae are sparsely hairy, the remainder being naked.

3. Terminal hook of the male right fifth foot *not denticulate* in *D. manitobensis*; *denticulate* in *D. leptopus* and in *D. piscinae*.

4. Second basal segment of left fifth foot of male with a narrow hyaline ridge or process running the length of the inner lateral margin in *D. manitobensis*; not present in *D. leptopus* nor in *D. piscinae*.

5. *D. manitobensis* is somewhat larger than is usual for *D. leptopus* or *D. piscinae*. No great significance is attached to this difference in itself, since factors such as water temperature might influence size.

In conclusion, the author is of the opinion that sufficient evidence has been presented to justify the establishment of the new species *Diaptomus manitobensis*. It appears to be closely related to *D. leptopus* Forbes.

This species was obtained from alimentary canals of young goldeyes, *Amphiodon alosoides* (Rafinesque), collected by Dr. W. M. Sprules from Head River Lake, Manitoba (53° 45′ N. Lat. 100° 35′ W. Long.).

The author wishes to express his thanks to Mr. H. C. Yeatman for kindly reading first and second drafts of this paper, and for helpful suggestions and criticisms. Thanks are also due to Carolyn Coker (former student in hydrobiology at the University of North Carolina) for tracings of drawings of *D. piscinae* from Mt. Lake, Virginia. These are reproduced by permission as Figures 4–7.

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SOME ESTERS OF THE ISOMERIC NITRO- AND AMINOBENZENESULFONIC ACIDS

By R. W. Bost and George F. Deebel*

The Venable Chemical Laboratory of the University of North Carolina Chapel Hill, North Carolina

While a few esters of the isomeric nitro- (1), (2), (5) and aminobenzenesulfonic (3), (6) acids have been reported, no systematic study of their preparation and properties has been made. By analogy with the corresponding aminobenzoic acid esters, it seemed desirable to ascertain if these compounds exhibited any local anesthetic activity.

We have prepared eighteen esters, fifteen of them new, of the isomeric nitrobenzenesulfonic acids by the following methods: reaction of the sodium alcoholate with the nitrobenzenesulfonyl chloride, an extension of Demeny's method; reaction of the alcohol with the nitrobenzenesulfonyl chloride in the presence of pyridine, which is an application of the method of Marvel and Sekera (4); and reaction of excess alcohol with the nitrobenzenesulfonyl chloride. All, except four, of these esters were reduced with stannous chloride at low temperatures to the corresponding aminobenzenesulfonic acid esters, which were characterized by the preparation of their hydrochlorides. Since none of the aminobenzenesulfonic acid esters here reported have been prepared previously by this method, our data substantiate the procedures used by other workers (3), (6).

All nitrobenzenesulfonic acid esters prepared were found to be quite stable and resistant to hydrolysis under storage conditions.

The esters of orthanilic and metanilic acids were found to be liquids and to hydrolyze so rapidly that they could not be isolated as the free bases. Their hydrochlorides were prepared and found to be sufficiently stable for analysis.

The esters of sulfanilic acid were all solids, with the exception of the n-butyl compound, and more stable than the ortho and meta isomers. On long standing most sulfanilic acid esters, except those containing a halogenated-alcohol moiety, were found to hydrolyze completely to sulfanilic acid and the alcohol.

The hydrochlorides of all the isomeric aminobenzenesulfonic acid esters, except those containing a halogenated-alcohol moiety, were found to lose all hydrogen chloride and to hydrolyze completely on long standing to form the free aminobenzenesulfonic acid.

In marked contrast to many of the esters of the aminobenzoic acids none of the esters of the aminobenzenesulfonic acids exhibited any local anesthetic activity.

EXPERIMENTAL

Preparation of the esters of the nitrobenzenesulfonic acids

(A) Sodium Alcoholate-Nitrobenzenesulfonyl Chloride Method. This method was found best for the preparation of the esters of unsubstituted and unsaturated

* Present address, Monsanto Chemical Co., Dayton 7, Ohio.

alcohols. Two and three-tenths grams of sodium was dissolved in the alcohol to be esterified. This solution was cooled and added slowly with stirring to 0.1 mole (22.1 g.) of the appropriate nitrobenzenesulfonyl chloride dissolved in 250 cc. of anhydrous ether. The reaction mixture was surrounded with an ice bath. The reaction was complete in about fifteen minutes, after which the ether and excess alcohol were removed by evaporation under an electric fan. The reaction product was washed with water and air dried. The crude ester was dissolved in ether, stirred with Norite and filtered. To the cold, colorless filtrate was added petroleum ether (b. 60–90°), whereupon colorless crystals of the ester were obtained in good yields.

(B) Alcohol-Nitrobenzenesulfonyl Chloride-Pyridine Method. This method was used to prepare esters of the halogenated alkanols. A mixture of 0.55 mole of the halogenated alkanol and 248 g. of pyridine was cooled to 10° with stirring, and 0.5 mole (110 g.) of the appropriate nitrobenzenesulfonyl chloride was added slowly. The temperature was allowed to rise to 20° during the four hours of stirring which followed the complete addition of the acid chloride. The mixture was allowed to stand two hours, then poured into a beaker containing 600 g. of cracked ice, 400 cc. of water and 300 cc. of conc. hydrochloric acid. The oil which separated soon crystallized. It was filtered, washed with ice water and dried. The ester was purified by dissolving in benzene, agitating with Norite, filtering and reprecipitating with petroleum ether (b. 60–90°).

(C) Alcohol-Nitrobenzenesulfonyl Chloride Method. The esters of β-diethylaminoethanol were prepared by this method. Considerable tar formation was encountered when attempts were made to prepare esters of this alcohol by the other mentioned methods. To a solution of 0.1 mole (22.1 g.) of the appropriate nitrobenzenesulfonyl chloride in 250 cc. of anhydrous ether was added slowly, with cooling and stirring, 24 cc. of β-diethylaminoethanol dissolved in 50 cc. of anhydrous ether. The mixture was allowed to stand fourteen hours, during which time a semisolid mass formed and partially crystallized. Decantation of the ether and addition of acetone to the sticky mass resulted in additional crystallization of the ester. The ester was recrystallized from 95% ethanol, by means of which it was separated from the β-diethylaminoethanol hydrochloride. The hydrochlorides of the esters were prepared in the usual manner by passing hydrogen chloride into a methanol solution of the ester and precipitating by the addition of dry ether.

Preparation of the aminobenzenesulfonates

The nitrobenzenesulfonates were reduced to the amino compounds by dissolving or suspending 0.2 mole of each in 300 cc. of glacial acetic acid, adding 0.6 mole of powdered stannous chloride and passing hydrogen chloride into the well-stirred mixture at a temperature below 48°. The temperature control was important to prevent hydrolysis of the ester. The solutions became clear after one or two hours time and were then allowed to stand an equal period before neutralizing below 18° with 25% sodium hydroxide. Temperatures higher than 18° during this latter operation resulted in hydrolysis of the esters. In many

cases the aminobenzenesulfonates precipitated and were filtered off; in others emulsions were formed which necessitated extraction with ether to effect isolation. Purifications were made through the hydrochlorides. Due to the ease of hydrolysis it was necessary to exercise care in controlling temperature and pH when the hydrochloride was converted to the free base. The aqueous solutions of the hydrochlorides were titrated to a pH of 7 below 18° and extracted with ether. These extracts were treated with Norite, filtered and the ester precipitated by the addition of petroleum ether (b. 60–90°). Good yields of pure white compounds resulted. Evaporation of the excess solvents, without heating, gave additional crystals. The compounds were all insoluble in water but soluble in ether and acetone and slightly soluble in ethanol. The allyl and β-diethylaminoethyl derivatives hydrolyzed before they could be isolated.

TABLE I

β-Diethylaminoethyl esters

BENZENE-SULFONATE	METHOD	% YIELD	M.P °C	FORMULA	SULFUR, %	
					Calcd.	Found
2-Nitro-	C	20	250	$C_{12}H_{18}O_5N_2S$	10.59	10.50
3-Nitro-	C	20	272	$C_{12}H_{18}O_5N_2S$	10.59	10.53
4-Nitro-	C	20	297	$C_{12}H_{18}O_5N_2S$	10.59	10.57

TABLE II

Hydrochlorides of β-diethylaminoethyl esters

BENZENE SULFONATE	M P °C	FORMULA	NEUTRAL EQUIVALENT	
			Calcd	Found
2-Nitro-	Subl. 300	$C_{12}H_{19}O_5N_2ClS$	338.5	341
3-Nitro-	Subl. 320	$C_{12}H_{19}O_5N_2ClS$	338.5	335.5
4-Nitro-	Subl. 326	$C_{12}H_{19}O_5N_2ClS$	338.5	347

Stability of metanilic acid esters

Ethyl metanilate, a brown liquid. solidifying at 18–19°, was prepared by method (A). An ether solution was dried over Drierite for fourteen hours and then filtered into a dry flask. The ether was removed under reduced pressure at room temperature by use of a Hyvac pump and then sealed to the atmosphere by means of a stopcock while still under vacuum. Within a few minutes solid material began to form. Two weeks later the flask was opened and the mass triturated with dry ether to remove the unchanged ester. The solid which remained was dissolved in cold absolute ethanol and reprecipitated by the addition of dry ether. The resulting white, water-insoluble compound was diazotized and coupled with β-naphthol to give a dye and fusion with potassium hydroxide converted it into 3-aminophenol.

Anal. Calcd. for $H_3NC_6H_4SO_2OH \cdot C_2H_5OH$: N.E., 219; S, 14.61%; C, 43.83%; H, 5.93%. Found: N.E., 219, 220; S, 14.66%; C, 43.44%; H, 5.33%.

TABLE III

4-Nitrobenzenesulfonates

ESTER	METHOD	% YIELD	M.P. °C.	FORMULA	SULFUR, %	
					Calcd.	Found
Methyl	A	84.3	91.5	$C_7H_7O_5NS$	14.74	14.70
Ethyl	A	54.6	90*	$C_8H_9O_5NS$	13.85	13.92
n-Propyl	A	83.6	72	$C_9H_{11}O_5NS$	13.06	13.22
n-Butyl	A	81.1	61	$C_{10}H_{13}O_5NS$	12.35	13.41
iso-Butyl	A	85.3	57	$C_{10}H_{13}O_5NS$	12.35	12.34
n-Amyl	A	70.5	56	$C_{11}H_{15}O_5NS$	11.72	11.87
iso-Amyl	A	70.5	62	$C_{11}H_{15}O_5NS$	11.72	11.77
Allyl	A	84.4	74.5	$C_9H_9O_5NS$	13.16	13.27
β-Trichloroethyl	B	64.4	119	$C_8H_6O_5NCl_3S$	9.56	9.55
β-Tribromoethyl	B	74.8	125	$C_8H_6O_5NBr_3S$	6.83	6.92

* Reported (ref. 2) 92°; (ref. 1) 91°; (ref. 5) 92–92.5°.

TABLE IV

2-Nitrobenzenesulfonates

ESTER	METHOD	% YIELD	M.P. °C.	FORMULA	SULFUR, %	
					Calcd.	Found
Methyl	A	88.9	60	$C_7H_7O_5NS$	14.74	14.81
Ethyl	A	82.3	34*	$C_8H_9O_5NS$	13.85	13.84

* Reported (ref. 2) 15° and b.p. 163–164° (abs. vacuum).

TABLE V

3-Nitrobenzenesulfonates

ESTER	METHOD	% YIELD	M.P. °C.	FORMULA	SULFUR, %	
					Calcd.	Found
Methyl	A	64.9	89	$C_7H_7O_5NS$	14.74	14.69
Ethyl	A	58.2	37*	$C_8H_9O_5NS$	13.85	13.74
n-Amyl	A	42	liq.	$C_{11}H_{15}O_5NS$	—	—

* Reported (ref. 2) 42°.

TABLE VI

Hydrochlorides of metanilic acid esters

ESTER	% YIELD	M.P. °C.	FORMULA	NEUTRAL EQUIVALENT	
				Calcd.	Found
Methyl	64.8	340 dec.	$C_7H_{10}O_3NClS$	223.5	221.9
Ethyl	74.2	340 dec.	$C_8H_{12}O_3NClS$	237.5	235
n-Amyl	42	340 dec.	$C_{11}H_{18}O_3NClS$	279.5	278.7

The methyl and n-amyl metanilates were similarly prepared and treated as was the ethyl ester above. Precipitation of the solids from absolute ethanol with

TABLE VII

Hydrochlorides of Sulfanilic Acid Esters

ESTER	M.P. °C.	FORMULA	NEUTRAL EQUIVALENT	
			Calcd.	Found
Methyl*	340 dec.	$C_7H_{10}O_3NClS$	223.5	222.3
Ethyl*†	340 dec.	$C_8H_{12}O_3NClS$	237.5	237.2
n-Propyl*	320 dec.	$C_9H_{14}O_3NClS$	251.5	252.5
n-Butyl*	330 dec.	$C_{10}H_{16}O_3NClS$	265.5	266.1
iso-Butyl	330 dec.	$C_{10}H_{16}O_3NClS$	265.5	264.4
n-Amyl	330 dec.	$C_{11}H_{18}O_3NClS$	279.5	280.9
iso-Amyl	330 dec.	$C_{11}H_{18}O_3NClS$	279.5	273.1
β-Trichloroethyl	190	$C_8H_9O_3NCl_4S$	341	342
β-Tribromoethyl	175	$C_8H_9O_3NClBr_3S$	474.5	462.2

* Reported (ref. 3).
† Reported (ref. 6).

TABLE VIII

Sulfanilic acid esters

ESTER	METHOD	% YIELD	M.P. °C.	FORMULA	SULFUR, %	
					Calcd.	Found
Methyl	A	50.0	92[a]	$C_7H_9O_3NS$	17.11	17.12
Ethyl	A	74.2	79–80[b, e]	$C_8H_{11}O_3NS$	15.92	15.85
n-Propyl	A	48.7	41.5[c]	$C_9H_{13}O_3NS$	14.88	14.77
n-Butyl	A	67.8	liq.[d]	$C_{10}H_{15}O_3NS$	13.97	—
iso-Butyl	A	45.4	50	$C_{10}H_{15}O_3NS$	13.97	14.01
n-Amyl	A	58.7	41	$C_{11}H_{17}O_3NS$	13.17	13.11
iso-Amyl	A	50.1	33	$C_{11}H_{17}O_3NS$	13.17	13.06
β-Trichloroethyl	B	50.0	95	$C_8H_8O_3NCl_3S$	10.50	10.55
β-Tribromoethyl	B	46.8	133	$C_8H_8O_3NBr_3S$	7.31	7.37

[a] Reported (ref. 3) 92.5–93°.
[b] Reported (ref. 3) 78.5–79°.
[c] Reported (ref. 3) 42.5–43°.
[d] Reported (ref. 3) below 0°.
[e] Reported (ref. 6) 78–80°.

dry ether gave white acidic compounds identical in properties. The compounds were diazotized and coupled with β-naphthol to give a dye.

Anal. Calcd. for $H_2NC_6H_4SO_2OH$:N.E., 173. Found: N.E., 179.

The analytical samples of the ethyl and n-amyl metanilate hydrochlorides were separately retained in cork-stoppered bottles for eight years and then reanalyzed. Negative tests were obtained for hydrogen chloride and ethyl and n-amyl groups. Titration of each sample gave N.E. values of 175 and 174 re-

spectively. Thus hydrolysis of the ester hydrochlorides had occurred and low boiling components had evaporated leaving metanilic acid.

Stability of orthanilic acid esters

Ethyl orthanilate, obtained by method (A), was found to be a brown liquid solidifying at −31.5° and giving a hydrochloride decomposing at 340° with a N.E. of 237.4 (theoretical 237.5). The free amine, when treated in the same manner as was its meta isomer in the preceding experiment, hydrolyzed to form orthanilic acid containing a molecule of alcohol of crystallization.

Anal. Calcd. for $H_2NC_6H_4SO_2OH \cdot C_2H_5OH$: N.E., 219. Found: N.E., 208. The compound was diazotized and coupled in the same manner as its meta isomer to give a dye.

Stability of sulfanilic acid esters

The esters and hydrochlorides of this series appeared to be quite stable when prepared eight years ago. Recently the cork-stoppered analytical samples still available were reanalyzed to give the following data:

The n-propyl, iso-butyl and n-amyl sulfanilates were found to be sticky, unhomogeneous masses of ester, alcohol and free sulfanilic acid. Trituration of each sample with ether to remove the alcohol and unhydrolyzed ester left sulfanilic acid identified by N.E. values of 173, 174 and 175 respectively.

The n-propyl, iso-butyl and n-amyl sulfanilate hydrochlorides were found to give negative tests for hydrogen chloride and the alcohol moiety. Titration of the samples gave N.E. values of 175, 188, 175, and 177 respectively.

The β-trichloroethyl and β-tribromoethyl esters and hydrochlorides were found to be stable and unchanged in their analyses and properties still giving the same m.p. and N.E. values as reported in Tables VII and VIII.

SUMMARY

Twenty-four new esters of the isomeric nitro- and aminobenzenesulfonic acids have been prepared, characterized and their relative stabilities studied.

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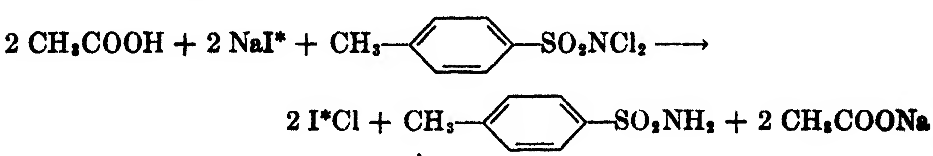
A STUDY OF THE CONDITIONS INVOLVED IN THE PREPARATION OF 3,5-DIIODO-4-OXO-1-PYRIDINE-ACETIC ACID (DIODRAST) CONTAINING IODINE-131

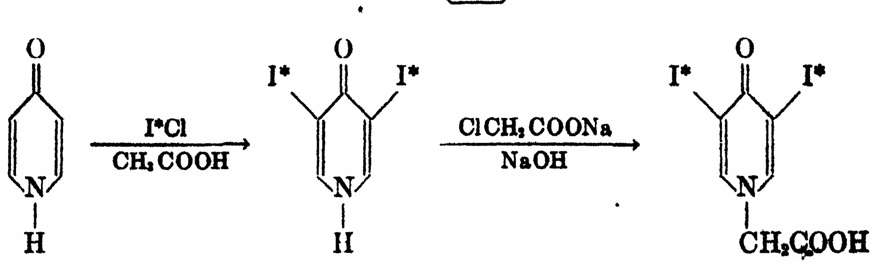
By Arthur Roe, R. L. Hayes, and H. D. Bruner

The Venable Chemical Laboratory and the Radioisotope Laboratory of the University of North Carolina
Chapel Hill, North Carolina

The compound 3,5-diiodo-4-oxo-1-pyridine-acetic acid, commonly called Diodrast (or sometimes diodone or perabodil) and usually employed in the form of the diethanolamine salt, has been extensively used for the clinical measurement of renal blood flow. It was of interest for several reasons to prepare the compound labeled with iodine-131; such a preparation had not been reported in the literature. No one of the several known methods of synthesis of diodrast proved to be entirely satisfactory when iodine-131 was involved because most of them employ an excess of the iodinating agent; this paper reports a satisfactory method of synthesis from 4-pyridone and sodium iodide-131 in yields of 84% (crude) and 73% (pure) based on the amount of sodium iodide-131 used. Synthesis using an exchange reaction between diodrast and sodium iodide-131 is currently being investigated.

The method chosen for the synthesis is illustrated in the accompanying equations; 4-pyridone is iodinated with iodine-131 monochloride to form 3,5-diiodo^{131}-4-pyridone; this compound when treated with monochloroacetic acid in alkaline solution forms the desired 3,5-diiodo^{131}-4-oxo-1-pyridine-acetic acid in good yield. The iodine-131 monochloride was prepared by allowing sodium iodine-131 to react with dichloramine-T.





Dohrn and Diedrich (1) have prepared inactive 3,5-diiodo-4-pyridone in good yield by iodination with iodine monochloride in dilute hydrochloric acid solution. Boyack, Moore, and Clausen (2) report the preparation of iodine-131 monochloride by the addition of sodium iodide-131 (along with inactive potassium

iodide as carrier) to an acetic acid solution of dichloramine-T; they used iodine-131 monochloride to prepare diiodo[131]-fluorescein in excellent yield using acetic acid as a solvent for the reaction.

One of the goals of the present synthesis was to achieve as high a yield of diodrast as possible with respect to the sodium iodide used as the source of iodine-131; the advantage of iodine monochloride over elemental iodine in this respect is obvious. An attempt was made to adapt the method of Boyack, Moore, and Clausen (2) to the preparation of 3,5-diiodo[131]-4-pyridone; the results at first were discouraging, but eventually a 91% yield of 3,5-diiodo[131]-4-pyridone was realized. During the course of this investigation it was found that the following factors have a pronounced influence on the yield and purity of the 3,5-diiodo[131]-4-pyridone obtained: (1) the point in the synthesis of iodine-131 monochloride at which the sodium iodide-131 is introduced; (2) the ratio of dichloramine-T used to that stoichiometrically required in the synthesis of iodine-131 monochloride; (3) the ratio of 4-pyridone used to that stoichiometrically required in the preparation of 3,5-diiodo[131]-4-pyridone; (4) the ratio of water to solvent acetic acid used. A discussion of these effects follows.

(1) The point at which the sodium iodide-131 was introduced in the preparation of iodine-131 monochloride was found to have a very decided effect on the yield of 3,5-diiodo[131]-4-pyridone with respect to the iodine-131 used. If, as was first attempted, the solution of sodium iodide-131 was introduced before the inactive potassium iodide carrier, the yield based on the amount of iodine-131 used was approximately half the yield based on the total amount of iodide used. For example, in one preparation when the sodium iodide-131 was introduced first the yield based on total iodide was 68.0%, whereas the yield based on iodine-131, as determined by the radioactivity of the product, was only 32.8%. If, on the other hand, the sodium iodide-131 was introduced immediately after the potassium iodide carrier, the two yields were approximately equal; thus in one experiment when the sodium iodide-131 was introduced last, the yield based on total iodide was 67.9%, and the yield based on iodide-131 was 68.1%. No reason for this behavior was found. (Much better yields were obtained in later experiments.)

(2) The ratio of dichloramine-T to sodium iodide-131 used in the preparation of iodine monochloride was found to be important. The directions given by Boyack, Moore, and Clausen (2) for the preparation of iodine-131 monochloride call for twice the stoichiometric amount of dichloramine-T. Analysis of the 3,5-diiodo-4-pyridone obtained using this twofold excess revealed the presence of considerable chlorinated 4-pyridone. A study was therefore made of the effect of excess dichloramine-T on the yield and purity of the product, other factors being held constant; the results of this study are shown in Fig. 1. It was found that an excess of dichloramine-T was necessary to prevent decomposition of iodine monochloride during the reaction with 4-pyridone; however, too great an excess brought about chlorination of the 4-pyridone. Under the conditions employed in this study the best yield of pure 3,5-diiodo[131]-4-pyridone was obtained using 1.05 times the stoichiometric amount of dichloramine-T. A study

of the other factors discussed below revealed, however, that higher yields of 3,5-diiodo[131]-4-pyridone could be obtained using 1.10 times the stoichiometric amount of dichloramine-T.

(3) Experiment showed that it was advantageous to employ an excess of 4-pyridone over that required for reaction with the iodine monochloride present. To determine the optimum amount of 4-pyridone, studies were made of the effect of varying the amounts of excess 4-pyridone on the yield of 3,5-diiodo-4-pyridone. Three parallel studies were carried out using 1.025, 1.050, and 1.100 times the stoichiometric amount of dichloramine-T. All samples of 3,5-diiodo-4-pyridone

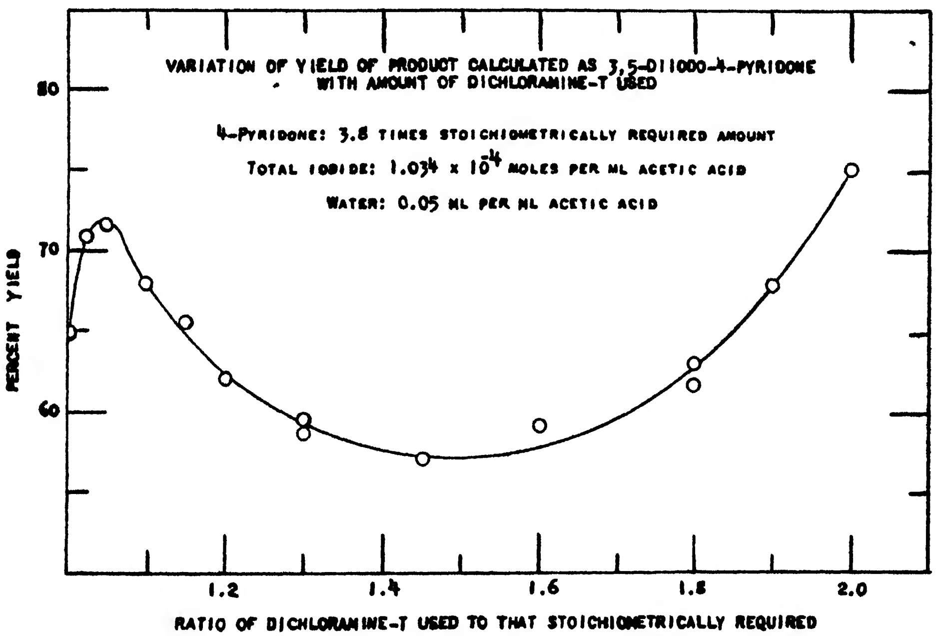


FIG. 1

prepared in this series of runs were pure, as indicated by iodine analysis. The results are shown in Fig. 2. As expected, the yield increased as the amount of excess 4-pyridone decreased. However, a maximum was reached in the neighborhood of 1.66 mole excess of 4-pyridone, after which the yield dropped; in each case this decrease in yield was attended by a more rapid onset and greater amount of decomposition of iodine monochloride. Using a large excess of 4-pyridone, the relative yields obtained with the three different amounts of dichloramine-T employed were those to be expected from the results shown in Fig. 1; however, using less than a twofold excess of 4-pyridone a reversal occurred, and the best yield of 3,5-diiodo-4-pyridone was obtained using 1.100 times the required amount of dichloramine-T rather than the 1.05 excess which Fig. 1 shows to be best.

Examination of Fig. 2 would indicate that the use of more than 1.10 times the

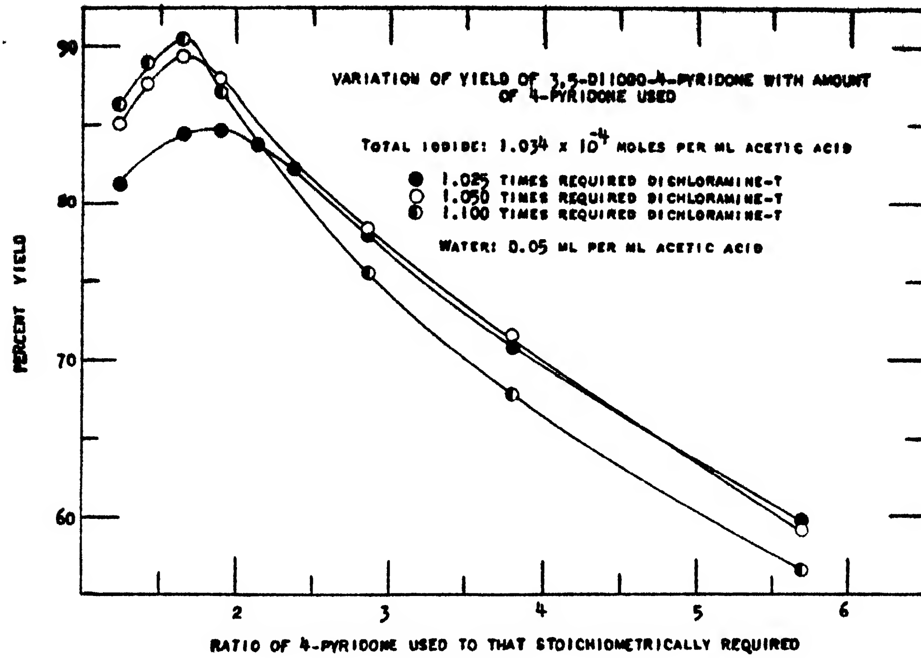

VARIATION OF YIELD OF 3,5-DIIODO-4-PYRIDONE WITH AMOUNT OF 4-PYRIDONE USED
TOTAL IODIDE: 1.034 x 10-4 MOLES PER ML ACETIC ACID
1.025 TIMES REQUIRED DICHLORAMINE-T
1.050 TIMES REQUIRED DICHLORAMINE-T
1.100 TIMES REQUIRED DICHLORAMINE-T
WATER: 0.05 ML PER ML ACETIC ACID
PERCENT YIELD
90
80
70
60
2
3
4
5
6
RATIO OF 4-PYRIDONE USED TO THAT STOICHIOMETRICALLY REQUIRED

FIG. 2

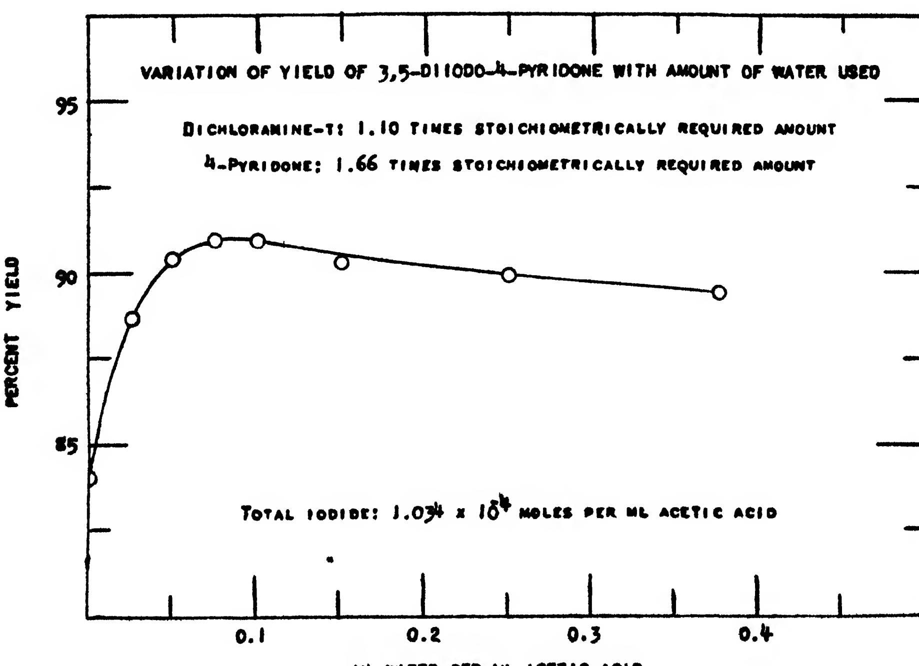

VARIATION OF YIELD OF 3,5-DIIODO-4-PYRIDONE WITH AMOUNT OF WATER USED
DICHLORAMINE-T: 1.10 TIMES STOICHIOMETRICALLY REQUIRED AMOUNT
4-PYRIDONE: 1.66 TIMES STOICHIOMETRICALLY REQUIRED AMOUNT
TOTAL IODIDE: 1.034 x 10-4 MOLES PER ML ACETIC ACID
PERCENT YIELD
95
90
85
0.1
0.2
0.3
0.4
ML WATER PER ML ACETIC ACID

FIG. 3

required dichloramine-T would increase the yield still further. A run was made using 1.15 times the stoichiometric amount of dichloramine-T; the yield was not as good as that reported above and analysis of the product showed it to contain only 98.9% of the necessary iodine, indicating that some chlorination had taken place.

(4) The use of an aqueous solution of sodium iodide-131 is the most convenient method of introducing it in the preparation of iodine-131 monochloride; a study was therefore made of the effect on the yield and purity of 3,5-diiodo^{131}-4-pyridone of diluting the solvent (acetic acid) with various amounts of water. The results of this study, in which 1.66 times the stoichiometric amount of 4-pyridone and 1.10 times the required amount of dichloramine-T were used, are shown in Fig. 3. All products were pure except that obtained in glacial acetic acid; presumably chlorination occurred here, as the product contained only 98.3% of the theoretical iodine. The yield remained approximately constant from a volume ratio of water to acetic acid of 0.375 down to a ratio of 0.050; thereafter it dropped decidedly. Here again, the decomposition of iodine monochloride, which occurred in the more concentrated acid solutions, appears to be the reason for this decrease in yield. With the use of larger amounts of water the preparation was rendered difficult by initial decomposition of the iodine monochloride which resulted in the collection of elemental iodine in the condenser. On the basis of this study a volume ratio of water to acetic acid between the limits of 0.075 and 0.100 was chosen as the best concentration to employ in the synthesis of 3,5-diiodo^{131}-4-pyridone.

No difficulty was experienced with formation of 3,5-diiodo^{131}-4-oxo-1-pyridine acetic acid from 3,5-diiodo^{131}-4-pyridone using an adaptation of the method of Baker and Briggs (3) for inactive material; yields were excellent in this step.

EXPERIMENTAL

In all studies on the factors influencing the yield of 3,5-diiodo^{131}-4-pyridone a constant total iodide concentration of 1.034×10^{-4} moles of iodide per ml. of acetic acid was employed. In all reactions reflux was continued until the reaction had approached completion, as evidenced by a complete or near complete discharge of color in the reaction mixture, or until extensive decomposition of iodine monochloride had set in, as indicated by the presence of free iodine. The yields of 3,5-diiodo^{131}-4-pyridone with respect to total iodide used were determined by collecting the products in weighed sintered glass crucibles; yields with respect to iodide-131 were determined by comparison of the radioactivity of the products with a standard dilution of the sodium iodide-131 solution used.

The analyses for iodine in 3,5-diiodo-4-pyridone were carried out by oxidation with acid permanganate using a modification of a method for diodrast reported by White and Rolf (4). On analysis the products obtained under the conditions indicated in Fig. 1 were found to be pure when less than 1.3 times the stoichiometric amount of dichloramine-T was used; beyond this limit the products became progressively more impure. The product obtained using 1.45 times the required dichloramine-T contained only 97.5%, and that obtained using 2.00

times the required dichloramine-T contained only 86.8% of the necessary iodine; the presence of chlorine in this product was established. All compounds obtained in the study shown in Fig. 2 were pure as shown by iodine analysis; likewise all products indicated in Fig. 3 were pure with the exception of the run made in glacial acetic acid. This product contained only 98.3% of the required iodine. To insure detection of all impurities all analyses were made on the crude products.

All operations with iodine 131 were carried out in a hood and monitored with a Tracerlab Monitor SU 3A. The operators wore rubber gloves, lead bricks were employed for shielding purposes, and a mirror was used for observations of the reaction mixture when long periods of reflux were required. Counting was done with an El-Tronics Scaler using an end-window thin-wall G. M. tube.

Preparation of Diodrast-I^{131}: The 4-pyridone used was prepared by the thermal decarboxylation of chelidamic acid (5) and was purified by distillation, recrystallization from water, precipitation from absolute alcohol with absolute ether, and drying at 115–120°; m.p. 148.5°. The dichloramine-T used was prepared by a method described by Krauss (6) and was purified by recrystallization from carbon tetrachloride; m.p. 83°. All materials used were stored over phosphorous pentoxide.

3,5-Diiodo^{131}-4-Pyridone: Exactly 1.100 g. of dichloramine-T was placed in a 250-ml. flat-bottomed flask with a 24/40 standard taper ground glass joint; 30 ml. of glacial acetic acid was added, and solution effected by heating. The flask was cooled to room temperature, 1.38 g. C. P. potassium iodide added, and the contents swirled until the iodide dissolved and the orange color of iodine monochloride appeared. The desired quantity of carrier-free iodine-131 as 3–4 ml. of an aqueous solution of sodium iodide-131 was introduced followed by 0.656 g. 4-pyridone. During the above additions, a further 10 ml. of glacial acetic acid was utilized in washing down the neck of the flask; at this point a total volume of 40 ml. of acetic acid had been used. A glass-sealed magnetic stirring bar was introduced, the flask fitted with a Liebig condenser, placed in a heating mantle, and the contents brought to reflux. Stirring was effected by a magnetic stirrer placed beneath the heating mantle. Precipitation of 3,5-diiodo^{131}-4-pyridone began before reflux had set in, and in order to prevent serious bumping after reflux had started it was necessary to maintain continuous and rapid stirring during the whole of the reflux period. Reflux was continued for five hours after which time the reaction mixture was colorless. After adding 46 ml. of water and cooling the flask in an ice bath for thirty minutes, the 3,5-diiodo^{131}-4-pyridone was filtered in the flask by introduction of a filter stick 10 mm. in diameter. The filter stick was connected to a filter flask which acted as a receiver for the filtrate, and thence through a trap to an aspirator. The filtered 3,5-diiodo^{131}-4-pyridone was then washed three times with ice water and used directly in the preparation of diodrast-I^{131}.

3,5-Diiodo^{131}-1-Oxo-1-Pyridine-Acetic Acid: Any adhering 3,5-diiodo^{131}-4-pyridone was washed from the filter stick as it was removed from the flask by the use of approximately 10 ml. of water; 2 ml. of a solution containing 0.57 g. of sodium hydroxide was added and the 3,5-diiodo^{131}-4-pyridone brought into

solution by heating. The flask was fitted with an adapter holding a Liebig condenser and an addition funnel, and, when the solution had reached the boiling point, 0.71 g. of monochloroacetic acid was added through the condenser, several ml. of water being used to wash down the condenser after the addition; the solution was stirred vigorously during this addition. The solution was refluxed for one and one-half hours, and then, while the solution was still hot, 1.75 ml. of concentrated hydrochloric acid in 2.5 ml. of water was added with vigorous stirring at a rapid rate through the addition funnel. After crystallization had set in, the flask was cooled for thirty minutes in an ice bath and the contents filtered in the flask as before with the aid of a filter stick; the diodrast-I^{131} was washed three times with the use of a minimum amount of ice water. A quantity of water (approximately 45 ml.) sufficient to bring the diodrast into solution on refluxing was added, 0.1 g. charcoal introduced, and the hot solution, after refluxing for several minutes, filtered with the aid of suction through two thicknesses of filter paper. The receiving filter flask was cooled in an ice bath for thirty minutes, and the precipitated diodrast-I^{131} transferred quantitatively, with the use of as little ice water as possible, to a weighed sintered glass crucible. The crucible was dried at 110° for two and one-half hours, placed in a desiccator, and then weighed. The crucible together with its known weight of diodrast-I^{131} was next placed in a Gooch funnel, the tip of which extended well into the neck of a 25 or 50 ml. volumetric flask which was in turn placed in a large filter flask. An amount of 0.5 N sodium hydroxide which was 2 or 3 ml. in excess of the volume necessary to dissolve the diodrast-I^{131} was run into the crucible from a burette. The addition was made in small portions, the contents of the crucible being thoroughly stirred with a pointed stirring rod after each addition and the dissolved diodrast-I^{131} then drawn with suction into the volumetric flask. After washing the crucible with small portions of distilled water, the calculated volume of 0.5 N hydrochloric acid required for back titration of the excess base was added and the flask then diluted to the mark.

In a typical preparation, where approximately 10 millicuries of sodium iodide-131 was employed, the yield of purified diodrast-I^{131} was 73.5% based on the amount of sodium iodide-131 used. The filtrate from the recrystallization of the crude diodrast-I^{131} contained 10.5% of the iodine-131 used, indicating a crude yield of 84.0%. A further 13.3% of the radioactivity was found in all other filtrates and washings, indicating a 97.3% recovery of the iodine-131 used.

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SUMMARY

3,5-Diiodo-4-oxo-1-pyridine-acetic acid containing iodine-131 has been synthesised in good yield; a study of the conditions involved in the reaction is reported.

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THE ODORS OF MONO- AND DIARYLALKANES

By Walter H. Hartung and Henry Dale Smith

School of Pharmacy, University of North Carolina
Chapel Hill, North Carolina

While pursuing studies with palladium catalysis Hartung and Hartung (1) reduced benzalacetophenone to 1,3-diphenylpropane. This hydrocarbon is not new (2), but the ease with which it may be obtained, its pleasant odor, and also the fact that monoarylalkanes possess distinctive odors (3) suggested the desirability of examining and comparing these and related substances for the relationship between their odors and chemical structure. The first study of such a comparison has been made possible by a grant from the Carnegie Foundation for the Advancement of Teaching, which is hereby gratefully acknowledged.

A tabular listing of the compounds thus far considered will serve to show their structural relationships and permit discussion of their aromas.

There is no satisfactory standard for measuring the quality or character of odors. Hence, for the present purposes only a general discussion and comparison will be attempted, and these will be given in brief paragraphs or sentences.

1. The most pleasant odors are found in the mono- and diaryl-propanes. Present evidence suggests that the corresponding methanes and ethanes are appreciably if not decidedly inferior to the propane homologs. The higher homologs, in so far as they have been compared, are also inferior. As evidence of this conclusion the following details may be cited:
   a) Phenylethane (II) is very reminiscent of toluene (I), whose odor is familiar. Phenylpropane (III) is much sweeter and, though not altogether pleasant, much less objectionable.
   b) The p-alkylanisoles, VI, VII, VIII, IX and X, compose an interesting series of homologs. The introduction of the p-methyl group into anisole, i.e., the methyl ether of p-cresol (VI), is markedly pleasanter than the unsubstituted anisole; p-ethylanisole (VII) is decidedly more pleasing; p-n-propylanisole (VIII) is very refreshing, quite like anethole; p-n-butyl-anisole (IX) is less pleasant again, perhaps even less so than the lower ethyl homolog.
   c) Methylenedioxyphenylmethane (XI) and methylenedioxyphenylpropane (XII) form a most unusual pair of homologs. The methane derivative is not pleasant, somewhat suggestive of naphthalene. The propane homolog, therefore, comes as a pleasant surprise with an odor as refreshing as that of safrole itself.
   d) The diphenylalkanes also fit into this general scheme. 1,3-Diphenylpropane (XV) is quite floral, suggestive of roses or iris. Diphenylmethane (XIII) is not unpleasant but certainly not floral. Diphenylethane (XIV) is, perhaps, intermediate between the two. Diphenylbutane (XVI) is again less pleasing, and 1,5-diphenylpentane (XVII) is practically odorless.

2. The introduction of a p-methyl group probably increases the pleasantness. The following observations are cited:
   a) p-Xylene (IV) is the least objectionable of the three isomeric dimethylbenzenes.

TABLE I

Monoarylalkanes

ARYL GROUP	METHANES	ETHANES	PROPANES	BUTANE
C_6H_5- (Phenyl)	C_6H_5 | CH_3 (I)	C_6H_5 | CH_2CH_3 (II)	C_6H_5 | $CH_2CH_2CH_3$ (III)	
C_7H_7- (p-Tolyl)	C_7H_7 | CH_3 (IV)	C_7H_7 | CH_2CH_3 (V)		
C_7H_7O- (p-Methoxy-phenyl-)	C_7H_7O | CH_3 (VI)	C_7H_7O | CH_2CH_3 (VII)	C_7H_7O | $CH_2CH_2CH_3$ (VIII)	C_7H_7O | $CH_2CH_2CH_2CH_3$ (IX)
			C_7H_7O | CH_2CHCH_3 | CH_3 (X)	
$C_7H_5O_2$- (3,4-Methylene-dioxyphenyl-)	$C_7H_5O_2$ | CH_3 (XI)		$C_7H_5O_2$ | $CH_2CH_2CH_3$ (XII)	

II, III, V, and VII were prepared by catalytic hydrogenolysis of corresponding ketone, Ar-CO-R.

IV obtained from Eastman Kodak Company.

VI and XI prepared by hydrogenolysis of corresponding aldehyde, Ar-CHO.

VIII and XII were prepared by hydrogenation of corresponding unsaturated compounds, anethole and isosafrole, respectively.

IX and X prepared by hydrogenolysis of corresponding carbinol intermediate, Ar-CHOH-R; the carbinol was obtained from the corresponding aldehyde, Ar-CHO and alkyl Grignard reagent.

   b) p-Ethyltoluene (V) is devoid of much of the toluene-like odor of ethyl benzene (II).
   c) 1-Phenyl-3-p-tolylpropane (XXII) is certainly as pleasant, and perhaps more so, than 1,3-diphenylpropane (XV).
3. The presence of a p-methoxyl group improves the odor of the monophenyl-

TABLE II

Diarylalkanes

<table>
<tr><th>METHANES</th><th>ETHANES</th><th>PROPANES</th><th>BUTANE</th><th>PENTANE</th></tr>
<tr>
<td>C_6H_5
|
CH_2
|
C_6H_5

(XIII)</td>
<td>C_6H_5
|
CH_2
|
CH_2
|
C_6H_5
(XIV)</td>
<td>$C_6H_5CH_2CH_2CH_2—C_6H_5$

(XV)

$C_6H_5—CH—CH_2CH_2—C_6H_5$
|
Cl
(XVIII)</td>
<td>C_6H_5
|
CH_2
|
CH_2
|
CH_2
|
CH_2
|
C_6H_5

(XVI)</td>
<td>C_6H_5
|
CH_2
|
CH_2
|
CH_2
|
CH_2
|
CH_2
|
C_6H_5
(XVII)</td>
</tr>
<tr>
<td>C_6H_5
|
$CH—CH_2CH_3$
|
C_6H_5

(XIX)</td>
<td>C_6H_5
|
$CH—CH_3$
|
CH_2
|
C_6H_5
(XX)</td>
<td>$C_6H_5—CH_2CHCH_2—C_6H_5$
|
CH_3
(XXI)

$C_6H_5—CH_2CH_2CH_2—C_6H_4—CH_3—p$
(XXII)
$C_6H_5—CH_2CH_2CH_2—C_6H_4—OCH_3—p$
(XXIII)
$C_6H_5—CH_2CH_2CH_2—C_6H_4—OC_2H_5—O$
(XXIV)
$C_6H_5—CH_2CH_2CH_2—C_6H_3:O_2CH_2—m,p$
(XXV)</td>
<td></td>
<td></td>
</tr>
</table>

XIII was purchased from Eastman Kodak Company.

XIV prepared by hydrogenolysis of benzoin (1).

XV, XXII, XXIII, XXIV and XXV were prepared by the hydrogenation of the corresponding benzalacetophenone intermediate, $C_6H_5—CO—CH:CH\text{-}Ar$, each of which was prepared from acetophenone and the appropriate aromatic aldehyde according to the directions for the synthesis of benzalacetophenone (4).

XVI prepared by the hydrogenolysis of 1,4-diphenyl-1-butanol; this was prepared by the reaction of hydrocinnamylmagnesium bromide on benzaldehyde (5).

XVII prepared by the reduction of cinnamalacetophenone.

XVIII obtained by the reaction of 1,3-diphenyl-1-propanol with hydrochloric acid; the intermediate carbinol was obtained by the reduction of benzalacetophenone (1).

XIX prepared by the hydrogenolysis of diphenylethylcarbinol; the carbinol was prepared from phenylmagnesium bromide and propiophenone (6).

XX prepared via 1,2-diphenyl-2-propanol by hydrogenolysis; the carbinol was obtained from phenylmagnesium and phenylacetone.*

XXI prepared via the carbinol intermediate obtained from the reaction of benzylmagnesium chloride with phenylacetone.* The identity of this hydrocarbon as obtained is open to doubt.

* The phenylacetone was supplied through the courtesy of Dr. M. L. Moore, Smith, Kline and French Laboratories, Philadelphia.

alkanes. In the diphenylalkanes it probably has no corresponding effect. The following observations support these conclusions:

a) The p-alkylanisoles are better than the corresponding alkylbenzenes or p-alkyltoluenes; e.g., VII is preferred to V and VIII is better than III.
b) 1-Phenyl-3-p-methoxyphenylpropane (XXIII) is not as desirable as diphenylpropane (XV) or phenyltolylpropane (XXII).
c) From observations recorded some time ago (3) it is known that p-n-propylanisole (VIII) is much better than m-n-propylanisole; and o-n-propylanisole is quite bitter.

4. The introduction of the o-ethoxyl group into diphenylpropane detracts from the favorable properties of the parent hydrocarbon.
5. The introduction of the methylenedioxy group into the 3,4-position of phenylpropane (XII) produces its own characteristic modification in the odor, yet produces a pleasing and refreshing effect.
6. It is possible that the presence of the methoxyl-, the ethoxyl- and the methylenedioxy-groups into diphenylpropane increases the vapor pressure to such an extent that their concentration in the atmosphere is below a favorable olfactory threshold.
7. The presence of a chlorine atom in the chain of diphenylpropane (XVIII) does not appreciably modify the odor.
8. The unbranched propane chain, and without further alkyl substitution in the chain, is superior. This is shown by:
   a) The pleasing character of the odor increases as one passes from 1,1-diphenylpropane (XIX) to 1,2-diphenylpropane (XX), reaching the peak in the isomeric 1,3-diphenylpropane (XV).
   b) 1,3-Diphenyl-2-methylpropane (XXI) is less pleasant.
   c) Isobutylanisole (X) is less desirable than p-n-propylanisole (VIII); although it is probably superior to p-n-butylanisole (IX).

SUMMARY

A comparison is made of the odors of twelve monoarylalkanes and thirteen diarylalkanes. In these compounds it is observed that the most favorable odors are associated with a straight-chain, unsubstituted propane chain. The presence of methyl, methoxyl and methylenedioxy groups in the aromatic nucleus of n-propylbenzene increases the pleasing properties. In the diarylalkanes, i.e., propanes, the effect is not so regular.

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A STUDY OF THE TRANSLOCATION OF RADIOACTIVE PHOSPHORUS IN LOBLOLLY PINE (PINUS TAEDA L.)*

By Donald E. Moreland

Division of Biological Sciences: Botany
North Carolina State College, Raleigh, North Carolina

Introduction

Information relative to the translocation and distribution of inorganic solutes and organic compounds and to the factors which influence these movements is essential for the interpretation and control of plant behavior. The problem of solute transport in herbaceous plants is still receiving active study. Much less attention, however, has been given the subject of solute movement in tree species. A knowledge of the physiological processes of trees is needed by the silviculturist and forest manager. Comprehension of the factors affecting the growth, development, and reproduction of commercially and economically important tree species is a prerequisite to successful forest management.

Several excellent reviews and critical discussions of solute translocation in plants have been published (Huber, 1932; Clements, 1934; Curtis, 1935; Mason and Phillis, 1937; and Crafts, 1939). Therefore, no attempt will be made to present an extended discussion of past work in this paper.

Solute transport was one of the first problems to interest students of plant physiology. Stephen Hales in 1727 reported the results of some of the earliest work attempted in this field. Since then, many investigators, using various techniques, have published the results of their studies on solute movement. The majority of these investigations, however, are subject to criticism because of the experimental procedures employed. Much of the work was based upon the application of indicators such as dyes or lithium salts, compounds not normally present in the xylary translocating system, to cut or severed surfaces. In intact plants the conducting systems are closed and the xylary system often exhibits tensions or pressures. Artificial openings into the conductive tissues introduce new factors which make the interpretation of experimental results questionable.

The development of suitable techniques utilizing radioactive isotopes permits studies of translocation to be made with arboreous vegetation under field conditions. In addition, it may be possible to eliminate many of the shortcomings and failures which characterize some of the original experimental techniques. Radioisotopes of several of the elements essential for normal plant growth are obtainable. These can be introduced to the transpiration stream through active absorption by meristematic root apices, the manner in which mineral elements enter the plant normally. When a radioelement is introduced directly into a plant or placed in its environment, the movement and presence of the

* Based on data presented in a thesis submitted to the faculty of North Carolina State College for the degree of Master of Science in Forestry.

radioactive variety can be traced independently of the stable isotopes of the same element already present in the system. This can be done rather easily and with a high degree of accuracy by detecting with suitable instruments the radiation emitted by the radioisotopes in attaining nuclear stability. Radioactive isotopes up to the instant of decay are, with the exception of a slight difference in mass, chemically and physically very similar to the normal isotopes of the same element. These differences are so small that it can be assumed that the isotopes of a given element are not utilized preferentially by the living organism. Injury to living cells may occur when high concentrations of radioelements are used; however, in biological investigations levels of activity are selected to minimize any injurious effects. It was assumed that the emitted radiation, under the conditions of this investigation, did not interfere with the normal physiological activities of the living cells of the trees that were treated.

The data presented here are the results of an exploratory study on loblolly pine (*Pinus Taeda* L.). Following these preliminary trials a general investigation has been initiated relative to the translocation of mineral salts in the roots and stems of certain species of trees under different seasonal and environmental conditions using radioactive isotopes.

MATERIALS AND METHODS

Phosphorus was selected for use in this investigation because of its physiological importance and the availability of a suitable radioactive isotope (P^{32}). It is one of the mineral elements essential to normal plant growth and is universally present in all forms of plant life. Past studies (Hevesy et al, 1936, 1937; Biddulph, 1940; Arnon et al, 1940) have shown that phosphorus is highly mobile within the plant and is readily redistributed from one plant organ to another. Small glass vials containing 25 milliliters of a prepared radioactive phosphorus solution with an adjusted pH of 5 were used in the field. Each milliliter of solution contained 140 micrograms of normal phosphorus and had a P^{32} activity level of 10 microcuries. It is not known if this one-salt solution had a toxic effect on the meristematic cells of the root tip. No indication was obtained of the magnitude of toxicity or of its influence, if any, on the rates of movement as obtained in this investigation under the short periods of time treatment was in progress. Additional study will have to be made of this point before a definite answer is available.

Plantation grown loblolly pine saplings 11 and 12 years old ranging in diameter from three to six inches were selected for study. The technique followed in this investigation began with the location of functional terminal or lateral root tips. Suitable tips could be found either directly under the decaying mat of needles cast on the forest floor or in the upper few inches of soil. The rootlet was very carefully uncovered for a distance of approximately twelve inches from the tip. A depression was made to hold the vial containing the radioactive phosphorus solution and the intact attached tip was lowered into it. At the end of the treatment period, which extended up to 10 hours, the rootlet was severed and the vial and treated tip were removed. The root was then traced back to its junction with the stem and the tree was felled. Cross-sectional samples one-inch thick

were obtained from the stem and root at two-foot (61 cm.) intervals. Following removal of the bark the outer three rings of xylem were separated from the stem sections for analysis. Root samples and the selected stem xylary tissue were split into sections approximately ⅛th-inch square and one-inch long. The "splinters" were placed in pyrex glass beakers of suitable sizes. Ashton (1936) has shown that in the presence of magnesium nitrate temperatures of 800°C. may be used without loss of phosphorus. Therefore, prior to ashing, the prepared samples were wetted with a minimum amount of 50 per cent ethyl alcohol to increase the penetration of the magnesium salt and flooded with a 5 per cent magnesium nitrate solution. Samples were next evaporated to dryness on an electric evaporating plate and were placed in an electric muffle furnace at a temperature of 250°C. After three hours, the temperature was raised to 450°C. and a clean, fluffy, white ash was obtained in approximately 12 hours. Each sample of ash was mixed thoroughly and representative decigram portions were weighed out and evenly distributed on 1¼-inch diameter aluminum counting discs. Disintegration activities were determined using standard laboratory Geiger scaling units. Counting data were corrected for background interference and the slight level of naturally occurring radioactivity present in control trees. Most of this can undoubtedly be attributed to a naturally occurring long-lived radioisotope of potassium, K^{40}. Activity over and above this absolute background value was interpreted as being due to P^{32}. The highest stem level at which a significant count could be recorded was selected to indicate the limits of movement of the introduced radiophosphorus.

EXPERIMENTAL RESULTS

The first treatments were made on August 31, 1949, in an 11-year-old loblolly pine plantation located near Franklin, Virginia. The fall phase of root development had begun and no difficulty was experienced in locating healthy functional root tips. Air temperatures ranged from 23.3°C. in the morning to 28.3°C. in the afternoon. The morning sky was clear with scattered clouds, a general overcast occurred about 1:00 P.M., and heavy rain fell in the late afternoon. Environmental conditions, considered as a whole, favored low to medium rates of transpiration. The mid-point of all treatments were centered as closely as possible at 12:30 P.M.

A partial summary of the results of this investigation is presented in Table 1. Rates of movement expressed both as feet and meters per hour are included in the last column. These figures indicate composite rates only since there was no way to separate root from stem movement. In addition, no allowance was made for time lapse between the absorption of an ion and its subsequent movement into the xylary elements and the sap stream pathway. However, comparisons between normal absorption by intact root tips and introduction of the tracer through severed root surfaces indicate that the initial absorption and release of an ion to the xylary translocation stream occurs almost immediately.

A second set of treatments was made on October 1, 1949, in a 12-year-old loblolly pine plantation at the Richlands Creek Farm Forest located approximately 6 miles northwest of Raleigh, North Carolina. Environmental conditions,

on the whole, should have been favorable for high rates of transpiration with considerable tension present in the xylary translocating system. The results of this treatment have also been included in Table 1.

TABLE 1

Summary of translocation rate studies on plantation grown loblolly pine saplings

DATE	TREE NO.	DIAM.*	STEM HEIGHT	TREAT-MENT TIME	LIMITS OF ACTIVITY			RATE OF MOVEMENT	
					Root	Stem	Total		
		In.	*Feet*	*Hours*	*Feet*	*Feet*	*Feet*	*Ft./hr.*	*M./hr.*
Aug. 31, 1949	1	4.8	26.9	9.90	5.5	22.0	27.5	2.78	0.85
	6	6.7	31.9	10.00	15.4	24.0	39.4	3.94	1.20
	11	4.6	28.4	5.90	5.1	14.0	19.1	3.24	0.99
	20	7.2	30.6	2.87	13.4	0.0	13.4	4.67	1.42
	21	3.8	26.9	0.73	3.0	0.0	3.0	4.11	1.25
Oct. 1, 1949	22	3.0	25.8	9.17	15.8	18.0	33.8	3.69	1.13

* Measured at 4.5 feet above average ground level.

TABLE 2

Distribution of radioactive phosphorus, P^{32}, in tree 6 (presented as counts per minute per decigram of ash)

ROOT (DISTANCE FROM STEM JUNCTION)	NET P^{32} ACTIVITY*	STEM (HEIGHT ABOVE ROOT JUNCTION)	NET P^{32} ACTIVITY*
Feet	*C/m/dg ash*	*Feet*	*C/m/dg ash*
0	919.20	2	162.48
2	1070.52	4	120.84
4	1566.12	6	187.14
6	3460.92	8	239.34
8	4101.00	10	204.48
10	5445.30	12	244.80
12	4620.54	14	163.86
		16	219.78
		18	105.82
		20	133.98
		22	78.80
		24	23.58†
		26	0.00

* Activity has been corrected for background interference.
† Limit of movement.

In the fall studies the fastest rates for combined stem and root movement were 1.20 and 1.13 meters per hour, respectively, for trees 6 and 22. The maximum translocation rates that have been obtained to date were 1.42 and 1.25 meters per hour for trees 20 and 21 which received comparatively short treatments. Movements here, however, were limited to the lateral roots.

Activity distribution levels for both root and stem sections of tree 6 are presented in Table 2. Trends in activity as shown here were typical of those

obtained for all trees in which a considerable range of movement was recorded. The extreme drop in activity between the root section at the stem junction and the first stem section, two feet above it, is also characteristic. This is another phase of the problem which requires further study before an explanation for the abrupt decrease in activity can be made.

An indication of the total radioactivity is not represented if upward movement occurred in more than the three outer growth rings in the lower stem sections. As was mentioned previously, only the outer three xylary rings were separated and ashed. The innermost rings were not considered primarily because the main objective here was to determine solely the presence of radioactive phosphorus and not the total activity at the various heights. MacDougal, Overton and Smith (1929) reported that the tension set up by the transpirational pull exerted by needles of the pine was directly transferred to the layers with which the needles were connected. This resulted in a more rapid movement of solutes through the second, third, and fourth annual layers nearest the cambium. Based on this information it was assumed that if the radioisotope was present at a particular height in the stem, it could be detected in the layers sampled.

GENERAL DISCUSSION

The rates for xylary translocation in loblolly pine saplings as determined in this study are for the most part higher than the published values obtained by other investigators. Groom (1910) reported rates varying from 0.3 to a maximum of 1.2 meters per hour for *Pinus sylvestris*. MacDougal (1926) indicated rates up to 0.15 meters per hour for *Pinus radiata*. Both of these investigators used dyes for indicators. Huber and Seith (Huber, 1932) using Thorium B as a tracer presented rates from 0.16 to 0.30 meters per hour for conifers in general. Huber and Schmidt (1936) found rates of movement difficult to measure in conifers with their thermoelectric method but reported that flow was mostly under 0.5 meters an hour. As far as could be determined there have been no data published previously relative to rates of movement in the lateral roots of conifers.

Rates of movement can be more fully appreciated if consideration is extended to the anatomical structure of the coniferous stem. Longitudinally oriented tracheids occupy 90 per cent of the total volume of the xylary stem tissue in loblolly pine (Forsaith, 1926). Vascular rays, radially aligned, and resin ducts, both horizontal and vertical, comprise the remaining 10 per cent. Brown, Panshin, and Forsaith (1949) report the mean length for the tracheid in the wood of *Pinus Taeda* to be 4.33 mm. with a standard deviation of 0.9 mm. The average distance covered by an ion moving in the sap stream passing in the longitudinal direction along a tracheal cavity is dependent not only on the length of the tracheid, but also on the overlap. Tracheal overlap is approximately one-fourth of a tracheid at each end (Stamm, 1946). Material being translocated may enter at any point over the overlap at one end and exit at any point in the overlap at the other end. The average tracheal path can be considered to be roughly three-fourths of a tracheal length. Stamm cites an average effective cavity tracheal length of 2.85 mm. for all softwood species. Thus, water and solutes in travel-

ling a distance of one meter along the stem longitudinally would have to pass into and through approximately 350 tracheids, according to his calculations. Conceivably, water and solutes moving longitudinally encounter a much greater resistance in the coniferous stem than in the angiospermous stem where vessels, xylary elements involved in the movement of water and solutes, sometimes attain a length of several meters.

The density of root tissue is less than that of stem tissue and root tracheids are longer and have a wider tangential diameter than those in the stem. In the macerated material examined tracheids as long as 9 millimeters were observed in root preparations. Walls of the root tracheids are also much thinner than those in the stem. Too, the extreme characteristic difference in cell wall thickness between spring- and summerwood tracheids is not apparent in the root elements. These structural differences may be correlated with reduced resistance to movement of the sap stream in the root. This in itself may partially account for the attainment of the fastest rates of movement in trees receiving short periods of treatment so that movement was limited to the lateral roots.

No attempt has been made to investigate the forces responsible for sap stream movement. This is still the subject of considerable controversy and is beyond the scope of the present study. As was stated previously, the objectives in the investigation being reported were to determine rates of movement and to develop techniques to be used in future studies.

SUMMARY

1. A technique has been presented for studying the rates and paths of mineral salt movement in tree species under field conditions using radioactive phosphorus, P^{32}, as a tracer.

2. The highest translocation rate obtained for the movement of P^{32} in the lateral roots of loblolly pine saplings was 1.42 meters per hour. The maximum determined rate for combined stem and root movement was 1.20 meters per hour.

3. Indications were obtained for faster movement in the lateral roots than in the stem. There is a direct correlation here between the anatomical structure of the two regions.

This study was conducted under contract with the Atomic Energy Commission through the Office of Naval Research. Radioactive phosphorus used in this investigation was supplied by the Oak Ridge National Laboratory, Oak Ridge, Tennessee, on allocation from the Isotopes Division, U. S. Atomic Energy Commission.

The writer wishes to express appreciation to Dr. D. B. Anderson for his assistance and guidance throughout the course of this investigation.

Appreciation is also extended to the staff of the North Coastal Plain Research Center, Southeastern Forest Experiment Station, United States Forest Service located at Franklin, Virginia, for their cooperation with the collection of the field data in the late August study.

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SOME PHYSIOLOGICAL ASPECTS OF FERTILITY IN ACHLYA TUBERCULATA*

By A. W. Ziegler and Betty Linthicum

Department of Botany, Florida State University
Tallahassee, Florida

In the course of an investigation of the water molds of Leon County, Florida, the senior author of this article found an undescribed species of *Achlya*. This form, named *Achlya tuberculata*, was isolated from a water collection taken from a cypress swamp (Ziegler, 1950). A striking peculiarity of this fungus can be seen when it is grown in charcoal filtered distilled water. Under these conditions more than half of the oogonia that develop contain eggs which disintegrate before reaching maturity. If the fungus is grown in an oak leaf decoction, however, 94–98% of the oogonia formed contain entirely mature eggs. The authors felt that the prevention of egg disintegration might lie in compounds released by the oak leaves or in differences in hydrogen ion concentration. In order to ascertain the reason for this peculiarity, several tests involving different dilutions with a close check on pH have been performed. The results of these experiments are reported in this paper.

Although many references can be found concerning the relationship of pH to vegetative growth, the writers have been unable to find any expressly dealing with the effects of hydrogen ion concentration on the maturation of sex organs in this group. Couch (1945–1947) reports (personal communication) that he and his students have used oak leaves, leaf decoctions, and tannic acid solutions to induce egg maturation and normal antheridial development in species of *Achlya*. Miss Josephine Stewart (1946) also used dead oak leaves and oak leaf decoctions with *Rhizophidium coronum* and got the best growth of this form in oak leaf decoctions.

Experimental Results and Discussion

In the first experiment, hemp seed cultures of the fungus were placed in oak leaf decoctions. A strong solution was made using the dried leaves of *Quercus nigra* L. This was then diluted with sterile charcoal filtered water until 6 different preparations of the decoction had been prepared. These, tested on a Beckman electric potentiometer, gave pH values of 7.9, 7.7, 5.9, 5.3, 5.0, and 4.7. These are used for designating the various solutions. A control grown in charcoal filtered distilled water of a pH of 8.1 was also used. Cultures were placed in the preparations and remained there 19 days. In all cases in these experiments, the cultures placed in the various solutions were the same age and had approximately the same amount of vegetative growth.

After the elapsed time, the cultures were examined. Four separate counts of

* Contribution number 42, Botanical Laboratory, Florida State University.

100 oogonia each were made for the different pH concentrations of oak leaves. The results are given in Table I as averages.

From the results it can be seen that in the concentration yielding a pH of 5.0 nearly all the oogonia formed contained eggs all of which matured. It appears that the increasing concentration of the oak leaf decoction apparently stimulated the production of mature eggs. A corresponding decrease in oogonia containing only disintegrated eggs and those with both mature and disintegrated eggs can be seen as acidity increases. The pH 5.9, however, seemed to be an exception to this general rule and we are not able to account for this occurrence.

At the end of this portion of the experiments there was still some question whether pH or oak leaf decoction concentration accounted for the increase in egg maturation, or some other factor—such as tannic acid concentration—might have played some part in the results obtained. Therefore, buffer solutions were

TABLE I

pH	% OOGONIA WITH MATURE EGGS ONLY	% OOGONIA WITH MATURE AND DISINTEGRATED EGGS	% OOGONIA WITH DISINTEGRATED EGGS ONLY
Control			
8.1	23	12	65
Experimental Solutions			
7.9	39	9	52
7.7	33	8	59
5.9	In this pH, vegetative growth was abundant but oogonia were so scantily formed that a count comparable to any listed above was impossible.		
5.3	48	23	29
5.0	94	1	5
4.7	No growth occurred		

made up using Sørenson's phosphate buffer solutions (McLean, 1941). These were verified by an electric potentiometer. Solutions with the following pH values were used: 8.0, 7.5, 7.0, 6.5, 6.0, 5.5, 5.0, and 4.5. A hemp seed culture of the fungus was placed in each dish containing the buffer solution. They remained in the buffer solutions 15 days. Three to four separate counts of 100 oogonia each were made for each culture. The averaged results are listed in Table II.

It can be seen from the data that an increasing acidity produces an increase in the number of oogonia which form mature eggs entirely—from 3% in pH 8.0 to 94% in pH 4.5. With this increase, a corresponding decrease of oogonia containing only aborted eggs occurs—from 95% in pH 8.0 to 1% in pH 4.5. An interesting development may be noted in the oogonia which contain both mature and disintegrated eggs. In pH 8.0, 2% of the oogonia formed in this manner. This percentage gradually rises to 20 in pH 6.5 and then suddenly declines to 5% in pH 4.5. This seems to be closely correlated, however, with the fact that between pH 7.0 and 6.5 there is a remarkable change in the percentages of the

oogonia containing only mature eggs and those containing only aborted eggs. For the oogonia which contain only mature eggs there is a steady progression from the 3% in pH 8.0 to the 94% in pH 4.5. Likewise, there is a steady downward curve for the oogonia with only disintegrated eggs from 95% in pH 8.0 to 1% in pH 4.5.

In both experiments, egg and oogonia size were normal for any pH. Therefore, the pH concentration apparently has no effect on oogonial or egg measurements. In this species, diclinous antheridia are scantily formed and occur mainly in young cultures in water with or without the addition of oak leaves. Throughout these experiments, we have seen no indication that the oak leaf concentrations or buffer solutions either increased or inhibited the antheridial growth.

Although discrepancies exist between the data obtained for behavior in oak leaf water and in buffer solutions, a study of both shows certain similarities between them. In general, there is a marked abortion of eggs in the 7.0–8.0 range,

TABLE II

pH	% OOGONIA WITH MATURE EGGS ONLY	% OOGONIA WITH MATURE AND DISINTEGRATED EGGS	% OOGONIA WITH DISINTEGRATED EGGS ONLY
8.0	3	2	95
7.5	3	3	94
7.0	7	4	89
6.5	61	20	19
6.0	79	13	8
5.5	88	9	3
5.0	92	5	3
4.5	94	5	1

while almost complete egg maturity is attained in solutions of pH 4.5–5.5 except in the oak leaf decoction extract of pH 4.7 where all growth was inhibited. With the rise in the percentage of oogonia all of whose eggs mature, there is a corresponding decrease in the percentage of oogonia whose eggs have disintegrated. The results obtained for oogonia which form both mature and aborted eggs is somewhat similar in both instances. There is a gradual rise from a pH of about 8.0 to an acid condition of 5.3 in the oak leaf concentration and 6.5 in the buffer solutions and then a gradual drop to a negligible percentage. The high point of the curve in both cases can be correlated with a sudden increase in the percentage of oogonia with mature eggs only and a sharp decline of those oogonia which contain aborted eggs only.

SUMMARY

The eggs of *A. tuberculata* when grown in charcoal filtered distilled water show a marked tendency to disintegrate before maturity. If cultures of this form are grown in oak leaf decoctions or in buffer solutions of acid pH value, the tendency to abortion is greatly lessened. Solutions with pH values of 4.5 to 5.0 are best to induce the production of oogonia containing matured eggs. Oogonia contain-

ing large numbers of disintegrating eggs are found in the 7.0 to 8.0 range. The results seem to indicate that egg maturation is influenced by the hydrogen ion concentration rather than by the organic compounds released by the oak leaves. Oogonium, egg size, and antheridial growth are not affected by pH. It is emphasized that these results apply only to this particular species of *Achlya*.

The authors are indebted to Dr. J. N. Couch and Dr. F. G. Gustafson for reading the manuscript and making excellent suggestions.

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STUDIES IN THE COMPOSITAE OF NORTH CAROLINA

III. An Enumeration of Noteworthy Distribution Records*

By R. K. Godfrey

Division of Biological Sciences: Botany, North Carolina State College
Raleigh, North Carolina

A previous similar enumeration of North Carolina composites was included in a paper on North Carolina vascular plants in general by Dr. William B. Fox and me,† and follows the general plan outlined therein. We expect to continue that series of notes on the distribution of North Carolina plants, but shall publish separately on the Leguminosae and Compositae, respectively, owing to certain practical considerations involving financial support for our field work. The field work and examination and study of herbarium material, which together resulted in these notes, was carried on while in residence in the Graduate School of Arts and Sciences of Duke University.

For the helpful criticism of Professor H. L. Blomquist, under whose guidance my work is presently proceeding, I hereby express my appreciation. I am grateful also for the courtesies and privileges which are always extended by Dr. A. E. Radford, Curator of the Herbarium, University of North Carolina, and by Dr. Thelma Howell, Director, Highlands Laboratory. To Dr. S. F. Blake, Botanist, Division of Plant Exploration and Introduction, Bureau of Plant Industry, Beltsville, Md., who read the manuscript and made helpful suggestions, I extend thanks.

The A. A. A. S. grant, through the North Carolina Academy of Science, awarded jointly to Dr. Fox and me in 1949, was used to defray a part of the expenses involved in my field work for the 1949 season.

Vernonia acaulis (Walt.) Gleason. Randolph County: along the railroad right-of-way, west of Ramseur, September 9, 1949, *Godfrey and Fox* 50297; dry sandy bank, 2 miles north of Randleman, June 29, 1927, *Wiegand and Manning* 3106 (in Gray Herb.); upland cut-over woods, on N. C. Rt. 902, 2.5 miles s.e. of Asheboro, July 5, 1949, *Fox* 2515; upland woods, on U. S. Rt. 64, 2 miles west of Asheboro, October 22, 1949, *Fox* 3501; Chatham County: abundant in a small, savanna-like bog just west of New Hope Creek, east of Pittsboro, along U. S. Rt. 64, August 21, 1949, *Godfrey and Fox* 50017; Anson County: shale bluff, Lane's Creek, 1.5 miles south of Rocky River, August 12, 1949, *Fox and Boyce* 2928.

* For the previous two papers in this series, see Godfrey, Studies in the Compositae of North Carolina, I. *Liatris*. Jour. Elisha Mitchell Sci. Soc. **64**: 241–259. 1948; II. The Compositae of Wake, Durham, and Orange Counties, l.c. **65**: 276–305. 1949.

† Fox, William B., and R. K. Godfrey, Notes on the Distribution of North Carolina Plants—I. Rhodora **51**: 129–146. 1949.

These are all piedmont stations for a plant heretofore not recorded for the piedmont province in North Carolina.

Elephantopus nudatus Gray. CHATHAM COUNTY: bog clearing, just west of New Hope Creek, east of Pittsboro, August 21, 1949, *Godfrey and Fox* 50018.

A plant primarily of the coastal plain, there being but one other record of its occurrence in the piedmont (Godfrey, 1949). This station extends it well into the latter province.

Eupatorium **Fernaldii**, nom. nov. (*Eupatorium album* L., var. *monardifolium* Fern. in Rhodora **39:** 451–453, 1937) BURKE COUNTY: broomsedge old field, along Catawba River opposite Rhodhiss, September 8, 1949, *Godfrey and Fox* 50282; BUNCOMBE COUNTY: abundant along railroad right-of-way, just east of Swannanoa, August 21, 1949, *Godfrey and Fox* 50010; RUTHERFORD COUNTY: abundant on steep hillside, cut-over woodland, south side of Lake Lure, August 16, 1949, *Godfrey and Fox* 49908; TRANSYLVANIA COUNTY: power line transect, steep mountain slope, just west of Horsepasture River, August 17, 1949, *Godfrey and Fox* 49953; MACON COUNTY: abundant in an old field, 4 miles east of Franklin, August 18, 1949, *Godrey and Fox* 49967.

Fernald (l. c.), in a synopsis of the varieties of *Eupatorium album* L., distinguished the variety *monardifolium* from the other varieties by its foliar characters, the leaves having coarser and more abundant teeth, harsher and firmer leaf-surfaces, rounded leaf bases and pinnate venation rather than tapering bases or 3-nerved venation. The heads of his var. *monardifolium*, however, are shorter, the phyllaries more herbaceous, much less attenuate at the tips than those of either var. *typicum* Fern. or var. *glandulosum* (Michx.) Fern. This fact is evident in the photographs accompanying the synopsis (l. c. Plate 484). In the field the former plant differs strikingly from the latter two, both in foliar characters and in the more technical characters of the heads. The differences being constant and clear-cut, I am giving it specific status which necessitates giving it a new name since "*monardifolium*" becomes a later homonym of *E. monardaefolium* Walp.

Eupatorium cuneifolium Willd. MOORE COUNTY: sandhills old field near Manly, along U. S. Rt. 1, September 15, 1949, *Godfrey* 50099.

The second record of occurrence in North Carolina, the other being for Brunswick County (Fox and Godfrey, 1949).

Liatris secunda Ell. ANSON COUNTY: turkey oak sand ridge near Sandy Plains Church, 1 mile west of N. C. Rt. 87, August 11, 1949, *Fox and Boyce* 2916.

Although most of the South Carolina citations of this species by Gaiser (1946) are from the sandhills region of the inner coastal plain, until now it has not been reported from the same physiographic region of North Carolina. All of ours have been from the two southeasternmost counties, New Hanover and Brunswick.

Chrysopsis pilosa Nutt. (*C. Nuttallii* Britton, not *C. pilosa* (Walt.) Britton in Small, 1933) HARNETT COUNTY: very abundant along the highway for 3–4 miles, approximately 3 miles southwest of Kipling, July 8, 1949, *Godfrey and Fox* 49428.

A plant of the South Central States, not previously recorded for our area, locally abundant at this station.

Chrysopsis pinifolia Ell. MOORE COUNTY: sandy place, Sept. 6, 1941, Schallert (in Herb. N. Y. Bot. Gard. as *C. aspera*); very abundant in sandhills old fields near Manly, September 15, 1949, *Godfrey* 50115.

This distinctive plant, reported for the state for the first time by Fox and Godfrey (1949), was found to be a dominant perennial in the sandhills old fields over an extensive area in and around Southern Pines and Pinehurst. There it so completely fills its ecological niche that one wondered the reason for its not having been seen, collected, and reported before. It was, therefore, a pleasure to find the Schallert specimen tucked away in the folder of *Chrysopsis aspera* at the New York Botanical Garden.

Chrysopsis trichophylla Nutt. BLADEN COUNTY: dry sandy turkey oak community, south side of White Lake, October 2, 1937, *Oosting* 1623 (in Herb. Duke Univ.); coarse white sand, scrub oak and long leaf pine sandridge, just northwest of White Lake, near the Prison Camp, July 9, 1949, *Godfrey and Fox* 49499.

Croom and Loomis (1833) included this plant in their New Bern Catalogue, and Wood & McCarthy (1886) listed it in the Wilmington flora. Curtis (1867) listed it for the Low Districts. Small (1933), however, ascribed to it the range ". . . . Fla. to S. C. and Miss., (La.?)."

Solidago flexicaulis L. MACON COUNTY: Highlands, Sept. 1902, *Harbison* (in Gray Herb.).

Included here because it is not in the checklist for the Highlands region by Quarterman and Keever (1947).

Aster mirabilis T. & G. ANSON COUNTY: Creek bank, foot of shale ridge, on Lane's Creek, 1½ miles south of Rocky River, August 12, 1949, *Fox and Boyce* 2930.

From 1835 until very recently this *Aster* was known only from a fragmentary collection from Columbia, S. C. In 1947 at the A. A. A. S. Meetings in Chicago, Cronquist reported upon several modern collections of it from the type locality, but it has remained unknown from elsewhere until this collection by Fox and Boyce.

Erigeron bonariensis L. (*E. linifolius* Willd.; *Leptilon linifolium* (Willd.) Small). CARTERET COUNTY: frequent on the waterfront and in gardens and vacant lots, Morehead City, August 3, 1949, *Godfrey* 49769; NEW HANOVER COUNTY: a very abundant weed in vacant lots and weedy places, Wilmington, June 14, 1949, *Godfrey* 49343.

Fernald (Rhodora **38**: 449, 1936), in reporting this plant for southeastern Virginia, extended the range northward from South Carolina. It is here newly recorded for North Carolina.

Gnaphalium calviceps Fern. HERTFORD COUNTY: weedy area around the fertilizer factory, Meherrin River at Murfreesboro, June 9, 1949, *Godfrey and Fox* 49222; GATES COUNTY: weedy area at a boat landing, east end of Chowan River bridge, N. C. Rt. 158 northeast of Winton, June 9, 1949, *Godfrey and*

Fox 49227; CURRITUCK COUNTY: weedy area at boat landing, Panther Landing, Northwest River below Moyock, June 10, 1949, *Godfrey and Fox* 49239; NASH COUNTY: street weed, Nashville, June 9, 1949, *Godfrey and Fox* 49216; EDGECOMBE COUNTY: sandy field, 1.3 miles east of Mildred, along U. S. Rt. 64, June 12, 1949, *Godfrey and Fox* 49326; TYRRELL COUNTY: roadside grass-weed border, 6 miles east of Creswell, June 12, 1949, *Godfrey and Fox* 49313; DARE COUNTY: weedy area around ferry landing, Roanoke Island, June 12, 1949, *Godfrey and Fox* 49304; HYDE COUNTY: dry soil of pine woods along Rose Bay Creek, near Swanquarter, June 26, 1935, *Correll* 1746 (in Herb. Duke Univ.); PAMLICO COUNTY: sandy soil, clearing on Neuse River, Camp Sea Gull, Minnesot Beach, June 11, 1948, *Godfrey* 48160; ORANGE COUNTY: weed on the campus, University of North Carolina, Chapel Hill, July 4, 1949, *Godfrey* 49384; WAKE COUNTY: garden weed, Longview Gardens, Raleigh, July 3, 1949, *Godfrey* 49382; DURHAM COUNTY: abundant in flower garden on Trinity Ave. near Watts St., Durham, May 23, 1950, *Godfrey* 50392; CUMBERLAND COUNTY: roadside grass-weed border, 5 miles south of Fayetteville along U. S. Rt. 301, July 8, 1949, *Godfrey and Fox* 49468; BLADEN COUNTY: sandy fallow field near Page's Lake, June 13, 1949, *Godfrey* 49334; BRUNSWICK COUNTY: abundant in sandy soil at roadside and edge of marsh, Brunswick River, on U. S. Rt. 17, May 21, 1949, *Godfrey* 49179.

Described from southeastern Virginia by Prof. Fernald (Rhodora **37**: 449–450, 1935), and subsequently found to be widespread in that area. This plant was first recorded for North Carolina by its inclusion in the catalogue of Wake, Durham, and Orange County composites (Godfrey, 1949). The citations above give some indication of its almost ubiquitous occurrence in the eastern part of the State.

Gnaphalium chilense Spreng. MARTIN COUNTY: old field, just above the paper mill, northeast of Plymouth, June 12, 1949, *Godfrey and Fox* 49323; DARE COUNTY: at base of Kill Devil Hill, July 3, 1939, *O. M. Freeman* (in U. S. Nat. Herb.); sand flats behind beach dunes, 2 miles north of Kitty Hawk Beach, June 10, 1949, *Godfrey and Fox* 49265; PAMLICO COUNTY: abundant in sandy old fields at Arapahoe, July 13, 1949, *Godfrey* 48322; CRAVEN COUNTY: 2 miles south of James City, *L. F. and F. R. Randolph* 550 (in Herb. Gray); ONSLOW COUNTY: very abundant in an old field, 2 miles south of Jacksonville on U. S. Rt. 17, June 21, 1948, *Godfrey* 48201; JONES COUNTY: wet sandy soil at Trenton, July 11, 1938, *Robert Gray* (in Herb. Duke Univ.); HOKE COUNTY: sandy old field, 1.5 miles south of the Moore County line, along U. S. Rt. 15 north of Laurinburg, June 27, 1949, *Godfrey and Fox* 49375; BLADEN COUNTY: sandy clearing, north shore of White Lake, July 9, 1949, *Godfrey and Fox* 49494.

Fox and Godfrey (1949) reported *Anaphalis margaritacea* (L.) B. & H. for the coastal plain of North Carolina. It was, however, *Gnaphalium chilense* Spreng. which I had misidentified as *A. margaritacea* and which it somewhat superficially resembles, and I am indebted to Prof. L. H. Shinners for the correction.* I am citing those stations again under the correct name, together

* By private communication.

with several additional ones found later. Insofar as I know, the species has not heretofore been recorded for the range of Small's Manual.

Gnaphalium peregrinum Fern. (*G. spathulatum* Lam. of authors) NASH COUNTY: street weed, Nashville, June 9, 1949, *Godfrey and Fox* 49215; DARE COUNTY: weedy area around ferry landing, Roanoke Island, June 12, 1949, *Godfrey and Fox* 49305; BEAUFORT COUNTY: sandy loam in an old field at Blount's Creek, April 5, 1939, *Godfrey, White and Shelbourne* 7049 (in Gray Herb.); PAMLICO COUNTY: sandy soil, clearing along Neuse River at Camp Sea Gull, Minnesot Beach, June 11, 1948, *Godfrey* 48161; ORANGE COUNTY: weed on campus, University of North Carolina, Chapel Hill, July 4, 1949, *Godfrey* 49383; WAKE COUNTY: Raleigh, June 4, 1924 (no collector's name on specimen); old field, Longview Gardens, east of Raleigh, May 9, 1948, *Godfrey* 49089; DURHAM COUNTY: abundant in a flower garden on Trinity Ave. near Watts St., Durham, May 23, 1950, *Godfrey* 50393; MOORE COUNTY: sandhills community, beside seepage bog in draw, 3 miles east of Southern Pines, April 10, 1949, *Frank W. and Sarah M. Woods*; BLADEN COUNTY: sandy fallow field near Page's Lake, June 13, 1949, *Godfrey* 49336; BRUNSWICK COUNTY: sandy loam, cultivated field, 2 miles south of Mill Creek Church, along N. C. Rt. 303, March 20, 1949, *Godfrey* 49008.

Small (1933) gives the range of this (as *G. spathulatum*) as "Fla. to Tex. (W. I.)." Blomquist and Oosting (1948) do not include it under either name for the piedmont of North Carolina. Fernald (Rhodora **45**: 479–480, 1943) gives its range as "Florida to Texas and Southern California, north, locally, to Southeastern Pennsylvania; eastern South America." The citations are given above to indicate that this is not an uncommon plant in our region.

Facelis retusa (Lam.) Sch.—Bip. (*F. apiculata* Cass.). CLEVELAND COUNTY: specimens (in Herb. N. C. State College) handed to Dr. G. K. Middleton, Dept. of Agronomy, for identification by a County Agent who took them from a field.

The range of this ruderal is given by Small (1933) as "Coastal Plain and Piedmont, Fla., Ala., and Ga."

Rudbeckia Heliopsidis T. & G. HARNETT COUNTY: peaty pocket, roadside clearing, 2 miles south of Lillington, along U. S. Rt. 15A, July 31, 1949, *Godfrey and Fox* 49757.

First report from outside eastern Alabama and western Georgia was by Prof. Fernald (Rhodora **42**: 496, 1940) for Prince George County, Virginia. This is, I think, the second.

Helianthus tomentosus Michx. HARNETT COUNTY: along the margin of a pine woodland where locally abundant, 6.5 miles north of Lillington, July 8, 1949, *Godfrey and Fox* 49433; CUMBERLAND COUNTY: dry pocosin, ½ mile southeast of Rockfish Creek, along N. C. Rt. 87, south of Fayetteville, July 26, 1949, *Godfrey and Fox* 49362; BRUNSWICK COUNTY: burned over shrub-bog, along Caswell Beach road near its junction with N. C. Rt. 130, August 20, 1948, *Godfrey* 48429.

These are coastal plain stations for a plant for which Small (1933) gives the range: "woods and hillsides, Piedmont and adjacent Blue Ridge, Ga. to Ala. and Va."

Coreopsis basalis (Dietr.) Blake (*C. Drummondii* T. & G.) BRUNSWICK COUNTY: abundantly naturalized in vacant lots, fields and roadsides in and around Southport, May 21, 1949, *Godfrey* 49167.

Small (1933) indicates that this plant has escaped from cultivation eastward of its natural range which is in "dry soil, and sandy prairies, Texas." Its occurrence as a volunteer in and around Southport is so extensive that at the time it blooms the many "unkempt" yards, vacant lots, and streets in the little town, and many roadsides and fields round about, are imparted a gaiety that is one of the well known charms of the place. It seems worthwhile, therefore, now to recognize the plant as a part of the flora.

Bidens pilosa L. NEW HANOVER COUNTY: sandy roadside, October 15, 1935, *P. O. Schallert* (in Herb. Duke Univ.).

An extension of range northward from southern Georgia.

Bidens polylepis Blake. (*B. involucrata* (Nutt.) Britton) SURRY COUNTY: abundant on dry old field slope, 4 miles east of Low Gap, September 6, 1949, *Godfrey and Fox* 50193; WAKE COUNTY: abundant in a moist grassy field, south of Garner, August 24, 1949, *Godfrey and Beaman* 50027; BRUNSWICK COUNTY: abundant in grass-weed border along roadside, River Road near Clarendon Plantation, August 25, 1949, *Godfrey and Beaman* 50041.

An extension of range southward from Virginia for which it was reported by Fernald (Rhodora **42**: 498, 1940).

Gaillardia lanceolata Michx. CUMBERLAND COUNTY: long-leaf pine, turkey oak sandhills, 5 miles south of Fayetteville, along U. S. Rt. 301, July 8, 1949, *Godfrey and Fox* 49455.

Biddulph (1944) gives the following distribution for this plant: "Longleaf, loblolly and slash pine forests of Florida, Georgia, Alabama, Louisiana, and Mississippi; . . ." The northeastern-most specimens she cites are from the sandhills region of South Carolina.—At our station the numerous specimens were all rayless.

Artemisia vulgaris L. WAKE COUNTY: abundant in a weedy vacant lot on South East St. in Raleigh, September 19, 1949, *Godfrey* 50067.

Too late to include it in the catalogue of Wake, Durham, and Orange County composites (Godfrey, 1949), I discovered that this wormwood is not uncommon in the vacant lots of certain parts of Raleigh. There were no specimens of it from this vicinity in the local herbaria.

Carduus acanthoides L. WATAUGA COUNTY: abundant locally in pastures and along roadside, north of Boone about 2 miles from the county line, Sept. 7, 1949, *Godfrey and Fox* 50253; BUNCOMBE COUNTY: Swiss dairy pastures, Asheville, Aug. 19, 1900, *C. Mohr* (in U. S. Nat. Herb.).

An adventive not previously recorded for North Carolina and the range of Small's Manual (1933).

Cirsium carolinianum (Walt.) Fern. & Schubert. (*C. flaccidum* (Small) Petrak) HENDERSON COUNTY: Flat Rock, July 22, 1898, *Biltmore Herbarium* 2014f (in U. S. Nat. Herb.); WAKE COUNTY: dry, open pine woodland and adjoining roadside bank, about 2 miles southeast of Raleigh-Durham airport, May 21, 1950, *Godfrey and Fox* 50388.

Fernald (Rhodora **45**: 509–510, 1943) indicates his doubtfulness as to whether this taxon occurs in North Carolina, although in Gray's Manual (1950) he gives North Carolina as the northeasternmost part of the range.

Cirsium Smallii Britton. NEW HANOVER COUNTY: frequent, sandy waysides, Wrightsville, June 22, 1950, *Godfrey* 50400.

An extension of range northward from South Carolina.

Centaurea maculosa Lam. ASHE COUNTY: West Jefferson, July 3, 1942, *Leroy R. Miller;* West Jefferson, September 10, 1944, *J. T. McLaurin;* ALLEGHANY COUNTY: grass-weed border on the road shoulder, Blue Ridge Parkway, 2 miles south of Wild Cat Rock, October 3, 1948, *Godfrey and Fox* 48638; WATAUGA COUNTY: Boone, July 26, 1932, *Blomquist* 5114 (in Herb. Duke Univ.); street weed in Boone, September 8, 1949, *Godfrey and Fox* 50257; YANCEY COUNTY: dry open soil along road, Harvard-Celo, August 11, 1935, *Correll* 3867 (in Herb. Duke Univ.); FORSYTH COUNTY: roadside, Ardmore, Winston-Salem, June 30, 1934, *P. O. Schallert* (in Herb. U. N. C.); roadside, on U. S. Rt. 421, 5 miles east of Winston-Salem, July 5, 1949, *Fox* 2514; MADISON COUNTY: Marshall, June 26, 1946, *J. E. Walker;* BUNCOMBE COUNTY: open roadside, Leicester, July 4, 1938, *Quarterman* 65 (in Herb. Duke Univ.); with no county indicated: found on road between Asheville and Blowing Rock, August 1929, *W. C. Coker*—with note on label, "Britton and Brown report it from Mass. to N. J. and Penn. . . . new to N. C.;" HAYWOOD COUNTY: Lake Junaluska, July 18, 1931, *Blomquist* 5113 (in Herb. Duke Univ.); JACKSON COUNTY: Pisgah Forest, July 25, 1940, *Helen Myers* (in Herb. U. N. C.); TRANSYLVANIA COUNTY: Pisgah Forest, on U. S. Rt. 64, July 25, 1940, *Helen Myers* (in Herb. U. N. C.); HENDERSON COUNTY: Camp Carlyle, Hendersonville, July 8, 1940, *Helen Myers* (in Herb. U. N. C.).

This adventive, now widely distributed in western North Carolina, is included in neither Small (1933) nor Blomquist and Oosting (1948). The Forsyth County records are the only ones, however, which would justify its inclusion in the latter. Jennison (Rhodora **37**: 309–323, 1935) reported it for a single locality in Tennessee.

Crepis capillaris (L.) Wallr. ASHE COUNTY: 3 miles north of Lansing, roadside, July 2, 1949, *Fox* 2467; YANCEY COUNTY: roadside, Burnsville, July 1928, *O. M. Freeman* (in Herb. Nat. Arb.); HAYWOOD COUNTY: moist, open pasture, Lake Junaluska, southwest shore, opposite golf course, June 28, 1938, *Quarterman* 46 (in Herb. Duke Univ.); roadside, Mt. Sterling, July 5, 1938, *Hall* 62 (in Herb. Duke Univ.); JACKSON COUNTY: yard, open shade, base of Wesner Bald, July 4, 1936, *Clabough* 318 (in Herb. Duke Univ.); TRANSYLVANIA COUNTY: road shoulder and pasture, on U. S. Rt. 64, 1 mi. west of Penrose, July 13, 1950, *Fox* 3984; MACON COUNTY: road shoulder and clearing, 1 mi. west of Wallace Gap on U. S. Rt. 64, July 13, 1950, *Fox* 4013.

Previously unreported for North Carolina, this species was first recorded for the range of Small's Manual (1933) by Jennison (Rhodora **37**: 309–323, 1935) for Tennessee.

Hieracium aurantiacum L. SWAIN COUNTY: moist ground among rocks, edge

of stream, north side of Soco Bald, July 12, 1937, *Blomquist* 9763 (in Herb. Duke Univ.); HAYWOOD COUNTY: Bunche's Bald, July 7, 1935, *B. W. Wells*.

First report for North Carolina and the range of Small's Manual (1933).

Hieracium pilosella L. ASHE COUNTY: moist open grassy soil on summit of Johnson's Knob, Big Tree Mt., May 26, 1939, *Correll and McDowell* 10885 (in Herb. Duke Univ.); ALLEGHANY COUNTY: near Twin Oaks, moist grassy mountain slope, May 26, 1939, *Correll and McDowell* 10815 (in Herb. Duke Univ.).

First published report for North Carolina and the Small's Manual range was by Godfrey (1949); it was based on one collection from Wake County.

Hieracium pratense Tausch. ASHE COUNTY: roadside near Watauga Co. line, June 15, 1938, *Totten* (in Herb. U. N. C.); ASHE-WILKES COUNTY LINE: roadside clearing, on Blue Ridge Parkway at Horse Gap, near N. C. Rt. 16, July 2, 1949, *Fox* 2455; SURRY COUNTY: open dry soil, Little Flat Rock, just east of Mt. Airy, May 25, 1939, *Correll and McDowell* 10740; STOKES COUNTY: near edge of Hanging Rock Park Lake, earthen dam, about 4 miles west of Danbury June 1, 1940, *Radford and Stewart* 477; WATAUGA COUNTY: roadside, between Blowing Rock and Boone, June 16, 1937, *Coker* (in Herb. U. N. C.); FORSYTH COUNTY: Winston-Salem, June 19, 1935, *Schallert* 8727; MITCHELL COUNTY: dry woods, Roan Mt., June 30, 1927, *Schallert* 8250 (in Herb. Duke Univ.); summit of Roan Mt., July 17, 1932, *Blomquist* 5230 (in Herb. Duke Univ.); Roan Mt., alt. 5500 ft., taking hold of fields and pastures here and all the way down to Blowing Rock, June 15, 1937, *Coker* (in Herb. U. N. C.); CALDWELL COUNTY: abundant on a steep bank at roadside, 2 miles from the Watauga Co. line, northwest of Lenoir, Sept. 8, 1949, *Godfrey and Fox* 50275; ALEXANDER COUNTY: Open woods on north side of Rocky Face Mountain, Hiddenite, May 29, 1941, *Keever* 330 (in Herb. Duke Univ.), YANCEY COUNTY: oak-shrub assoc., Newdale olivine deposit, 1¾ miles east of Micaville, Sept. 6, 1946, *Radford* (in Herb. U. N. C.); HAYWOOD COUNTY: Lake Junaluska, June 13, 1930, *Blomquist* 5235 (in Herb. Duke Univ.); HAYWOOD-BUNCOMBE COUNTY LINE: pastured area surrounding olivine deposit, Newfound Gap olivine deposit, 15 miles west of Asheville, May 28, 1947, *Radford* (in Herb. U. N. C.); MACON COUNTY: roadside, well drained, 4.8 miles from Highlands toward Cashiers, June 9, 1944, *Quarterman* 852 (in Herb. Duke Univ.).

Although not in Small (1933), Quarterman and Keever (1947) have this species in their summer check list of Highlands plants, and Blomquist and Oosting (1948) list it (as rare) for the piedmont, North Carolina. These citations indicate that it is widespread in the North Carolina Mountains.

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THE UMBELLIFERAE OF NORTH CAROLINA AND THEIR DISTRIBUTION IN THE SOUTHEAST*

By Charles Leland Rodgers

Department of Botany, University of North Carolina
Chapel Hill, North Carolina

Plates 13–21

Introduction

Although Europeans had previously published general treatments of the Umbelliferae, it was not until 1888 that John M. Coulter and J. N. Rose did a major revisionary work on this family for North America. After acquiring a broader knowledge of the family, they published (1900) a monograph which they considered to be a more natural presentation. By that time it was generally recognized that affinities of genera and species in this group were best indicated by fruit characters, and they and subsequent authors of regional manuals continued to rely upon these characters. The Umbelliferae in North America were monographed again in 1945 by Mildred E. Mathias and Lincoln Constance, who produced a very usable manual rich in synonymy.

In the South, Thomas Walter's scholarly classic, *Flora Caroliniana*, appearing exactly one hundred years before Coulter and Rose's monograph, was the first of a series of general floras of this region. In fact, this pioneering work seems to have been tremendously important in stimulating and setting a pattern for similar endeavors elsewhere in this country. A more comprehensive two-volume flora covering South Carolina and Georgia was completed by Stephen Elliott in 1824. Later a flora of the southern states, including North and South Carolina, Georgia, Florida, Alabama, Mississippi, and Tennessee, was prepared by Dr. A. W. Chapman, a Florida physician. This book went through three editions from 1860 to 1897. This was followed in 1903 by J. K. Small's *Flora of the Southeastern United States*, covering the same territory and in addition a considerable area west of the Mississippi River. Small's more recent *Manual of the Southeastern Flora* (1933) is limited to the area east of the Mississippi, and is the most complete work on this region.

No previous attempt has been made to treat comprehensively the Umbelliferae of North Carolina. A number of earlier local and out-of-state botanists have collected specimens and published their observations. In North Carolina, the most active botanists before 1900 were Croom, Loomis, Curtis, de Schweinitz, McCarthy, Wood, and Hyams. H. B. Croom and H. Loomis compiled (1833) a list of plants found in the New Bern area at approximately the same time the

* A thesis submitted to the Faculty of the University of North Carolina in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Botany. The author's present address is Route 1, Taylors, S. C.

Rev. Moses A. Curtis was cataloguing them for Wilmington and the Rev. L. D. de Schweinitz was actively studying them around Winston-Salem. Four years later Croom expanded his earlier work; and still later (1867) Curtis completed a catalogue of plants for the entire state. Additions to Curtis' catalogue were made by M. E. Hyams eighteen years later. Curtis' earlier flora of the Wilmington region was followed in 1886 by a Wilmington flora done jointly by Thomas F. Wood and Gerald McCarthy. His state flora was also followed by C. W. Hyams' *Flora of North Carolina* in 1899.

After 1900, published reports including references to Umbelliferae are chiefly of the nature of local floras or ecological studies. While it is impossible in some cases to tell precisely in what county a plant was observed, they do help to give an over-all picture of distribution. The following reports are some of the more useful for the present study: E. R. Memminger (Henderson County, 1915), I. F. Lewis (Shackleford Bank, 1918), W. L. McAtee (Church's Island, 1919), D. C. Peattie (Tryon Region, 1928–1930), B. W. Wells (Natural Gardens, 1932), Elsie Quarterman and Catherine Keever (Highlands Region, 1947), H. L. Blomquist and H. J. Oosting (Spring and Early Summer Flora of the Piedmont, 1948), A. E. Radford (Flora of Olivine Deposits, 1948); and W. B. Fox and R. K. Godfrey (Notes on Distribution, 1949).

This paper is an attempt to make the most of all available collections and published reports in conjunction with information gained from intensive field collecting during the entire growing season of 1949. This survey includes collections from every county of North Carolina and from every type of habitat. Since North Carolina is only a cross-section of three large physiographic regions, —mountains, piedmont, and coastal plain,—it seems best to include in this consideration all North Carolina species throughout their entire range. However, distributional data are recorded only for the Southeast, corresponding to the area of Small's *Manual*. Specimens studied from all states except North Carolina were from herbaria.

This study is not an attempt at revisionary work, the nomenclature being almost exclusively that of Mathias and Constance in *North American Flora*. The order of genera varies a little from the usual presentation to be consistent with some suggestions of affinity which are to follow later. The descriptions are for the most part from actual observations except in some cases of maximum size measurements. Unless an obvious error was indicated, the largest measurements recorded are usually used here.

A tabulation of all the records examined indicates that 34 genera, 59 species, and 4 varieties of Umbelliferae actually grow or have grown in North Carolina. Of this total, 44 species and 2 varieties are native, and 15 species and 2 varieties are introduced. The presence of one or two species is doubtful, and additional introductions in the future are probable. With this in mind, both the doubtful species and the most likely introductions are included in the keys.

ECONOMIC IMPORTANCE

Some of the Umbelliferae have been of considerable economic importance for a long time. Their uses are varied, some being used for foods, flavoring, or medi-

cines. Others have a negative value in that they are deadly poisonous to human beings or livestock when eaten by mistake, and a few are distinct nuisances as weeds. Of all the Umbelliferae in North Carolina, Queen Anne's Lace is definitely the most annoying and widespread weed, though on the other hand it is widely used for decorative purposes. Water Hemlock (*Cicuta*) grows in all sections of the state in bottom land. It is said to be deadly poisonous, especially the roots. Poison Hemlock (*Conium*), an uncommon introduction, is another deadly poisonous species. Although the fruits are most dangerous, it should never be grown where children might be tempted to chew it or to make blow-pipes from its hollow stems.

The members of this family still recognized in the *United States Pharmacopoeia* or the *National Formulary*, or in both, are Anise, Asafetida, Caraway, Coriander, Fennel, and Parsley.

TAXONOMIC CRITERIA

For a long time fruit characters have been used as the best indicators of relationships in the Umbelliferae. Other characters were thought to be either too uniform or too variable to be of much help except in a limited sense. The following evaluation of characters will show why some are more usable than others.

Roots. In spite of the numerous modifications to which roots are subjected, some characters are predictable under average conditions. A few examples are toproots in *Daucus*, club-shaped or obovate tuberous roots in *Oxypolis ternata*, fleshy-fibrous roots in *Sanicula smallii*, and black roots in *Sanicula marilandica* and *S. gregaria*.

Leaves and *stems* are often so variable within a genus or species that they are of little use in considering relationships. Conversely, they are so similar in some different genera that it is difficult or impossible to distinguish them without flowers or fruits. Such a difficulty is encountered in *Spermolepis divaricata* and *Apium leptophyllum* or in *Thaspium trifoliatum* and *Zizia aptera*. Leaves are often influenced to a considerable degree by environmental conditions. *Oxypolis rigidior* demonstrates nicely the extent of variation possible. However, leaf differences are very useful in separating species in the genus *Oxypolis*.

Inflorescences. All of the species of *Hydrocotyle* in this region can be distinguished by obvious differences in their manner of floral display. Likewise, *Torilis nodosa* and *T. japonica* can be so distinguished. Yet there are many genera which have similar inflorescences. Bentham and Hooker laid great stress on whether the umbels were simple or compound. Actually they may vary on a single plant, as in *Chaerophyllum tainturieri* and *Scandix pecten-veneris*. Sometimes it is difficult to tell whether they are simple or compound, as indicated by interpretations placed on the inflorescences of *Sanicula*. Coulter and Rose, Britton and Brown, Gray, Small, and Mathias and Constance describe the umbels as being irregularly compound and few-rayed. Actually, the "umbelets" are homologous to the heads of *Eryngium* and should be considered simple umbels. Just as in *Eryngium*, they are cymosely arranged. When examined with this in mind, the "irregular compound few-rayed" umbels no longer appear irregular or few-rayed but conform to a regular cymose pattern.

Typically, *Sanicula's* simple stalked umbels are subtended by one to several, usually 2–4, branches longer than the peduncles and bearing a stalked umbel subtended by branches. This branching or compounding continues until the branches subtending the terminal umbels fail to develop, and may occur four or five times before it stops. This type of branching is interesting in terms of the usual display of inflorescences in Umbelliferae where they nearly always, if not always, occur opposite the leaves (sometimes obscure if leaves are extremely reduced). This arrangement is interpreted as terminal. By shortening one or more internodes so that the nodes are brought together, the cymose pattern of floral display can be produced. All degrees of shortening of the internodes have been observed between the normal length and a whorled condition with one terminal inflorescence and several whorled (axillary) branches.

Bracts. The variability in shape and number of bracts minimize their usefulness as diagnostic characters in many genera and species. Extremes in irregularity are encountered in *Ptilimnium costatum* where the bracts are simple to pinnate. On the other hand, they are constantly absent in some species and always present and highly uniform in others.

Bractlets, generally present in compound umbels, are monotonously simple and less useful than bracts.

Calyx-teeth are usually absent or uniform and small. Best use of these characters is made in the genera *Sanicula* and *Eryngium*, where they are well developed and persistent in the fruits.

Petals and other floral parts have never been used extensively for the probable reason that they are small, fairly uniform, and relatively short-lived. Although the petals are generally much alike, some differences in shape, presence or absence of pubescence, or color are distinct enough for use. Perhaps the tendency to zygomorphy and the nature of petal tips are even more significant.

Contrary to the usual pattern in Umbelliferae, *Hydrocotyle* and *Centella* have straight petals or at the most concave, certainly not recurved at the tip. This is occasionally true of some genera and species in another subfamily. Besides the tip character, petals may be erect or spreading at maturity. Apparently this is a characteristic of genera or larger categories. The usefulness of such a character is limited because of the uncertainty of knowing whether the flowers are completely mature or not.

Stamens are too ephemeral and uniform to attract much attention. The major variations not to be overlooked are color and length as compared to the petals.

Styles are like the stamens in being variously colored and included or exserted They offer considerable difficulty at times in determining their length due to the uncertainty of knowing whether or not they have reached their maximum development.

Stylopodium or *disk*.—Whatever the true nature of these glandular structures, they are major taxonomic features. Their size, shape, lobation, and relation to the styles are distinctive. If the style projects from the top, the structure is called a stylopodium; and if the style is separate and surrounded by it, the structure is called a disk. As the name implies, the stylopodium is usually con-

sidered to be the foot of the style. It could be that the style is simply fused with the disk.

Fruits.—Completely mature fruits provide the characters which seem to indicate relationships best. The differences in wall structures, ribs, oil-tubes, carpophores, shapes, and directions of flattening afford the major bases for separating subfamilies, tribes, genera, and to a lesser degree species.

The walls of the pericarp in most Umbelliferae have strengthening cells located in the ribs or endocarp. A majority of species have primary ribs only, but several have secondary ribs, some of which are more prominent than the primary ones. Ribs may be obscure, in which case the walls are often covered with bristles or scales. Oil-tubes are usually between the primary ribs and on the commissure. Noticeable variants from that pattern are *Sanicula* and *Eryngium* in which oil-tubes are located in the primary areas and *Hydrocotyle* in which they are usually absent. The carpophore is distinct in most members of one subfamily. Its chief variation is in the extent of longitudinal splitting.

One of the most obvious differences in fruits is the direction of flattening. *Hydrocotyle* and *Centella* have fruits extremely flattened at right angles to the line where the carpels fuse (lateral); and *Pastinaca* and *Heracleum* have fruits flattened parallel to the line of fusion (dorsal). The flattening is effected at various times in the development of the different species. In *Hydrocotyle*, lateral flattening of the ovary is evident in very young buds, yet the ovaries are not as extremely flattened as the fruits. In *Pastinaca sativa* and *Angelica triquinata* the ovaries in the buds are actually laterally flattened while the fruits are dorsally flattened. In *Angelica venenosa* dorsal flattening is later, the ovaries of flowers being somewhat laterally flattened. A further delay in dorsal flattening is in *Oxypolis rigidior*, *O. ternata*, and *O. filiformis* where the ovaries of buds and flowers are distinctly laterally flattened and where fruits mature distinctly dorsally flattened.

Seeds have several useful characters when they are thoroughly mature. Their commissural faces may be deeply grooved, concave, or plane; they may or may not be grooved under the oil-tubes. Internally, they vary in degree of oiliness. Seed characters are more difficult to use since they require sectioning of fruits.

Chromosomes have been counted in only a few cases, chiefly in cultivated and European species. Only two or three species native to the Southeast have been examined. A summary of all counts indicates that the chromosome numbers are almost constant in the subfamilies (Wanscher, 1934).

INTERRELATIONSHIPS

Any conclusions about relationships drawn from knowing many species over an extensive geographical area would be better than decisions based on any less comprehensive knowledge. Although recognizing that there are limitations to making extensive conclusions, it is believed that sufficient information is at hand to warrant a discussion of affinities in some cases, particularly where the group is well represented in this area.

A look at the differences in Bentham and Hooker's and Drude's (in *Pflanzen-*

familien) attempts to produce a natural system of classification for the Umbelliferae shows the uncertainty of what characters should be given most weight in determining relationships. Both recognize three series or subfamilies based on different characters.

Bentham and Hooker's series Heterosciadiae (including *Hydrocotyle*, *Sanicula*, and *Eryngium*) usually has simple umbels and no oil-tubes at or near the depressions; series Haplozygiae has compound umbels, only primary ribs of fruit conspicuous, and usually oil-tubes at or near the depressions; and series Diplozygeae has compound umbels and depressions over the oil-tubes thickened or drawn-up into secondary ridges (ribs). They considered the nature of the umbels and oil-tubes of primary importance.

Drude's subfamily Hydrocotyloideae (including *Hydrocotyle*) has fruits with woody endocarps, no free carpophores, and oil-tubes absent or sunk in the main ribs only; and subfamily Saniculoideae (including *Sanicula* and *Eryngium*) has soft parenchymatous endocarps, exocarps usually with appendages, styles surrounded by disks, and oil-tubes various. These two subfamilies correspond to Bentham and Hooker's series Heterosciadiae. His third subfamily, Apioideae, has soft parenchymatous endocarps (sometimes with subepidermal layers of wood fibers), styles on apexes of disks, and oil-tubes various. This subfamily includes a group with secondary ribs which corresponds to Bentham and Hooker's series Diplozygeae.

A comparison of the two systems indicates that the sequence is similar, but that lines are drawn at different places. Considering the sum of all characters, it seems that the system of Drude is better. It is based on a shift of emphasis from the nature of the inflorescence to the nature of the fruit.

Subfamily Hydrocotyloideae is represented here by *Hydrocotyle* and *Centella*. There is no doubt that they are close. Besides the characteristics already listed, they have extremely laterally flattened fruits (Figs. 1 & 2), straight and spreading petals, stamens about length of petals, stamens and pistils maturing at about the same time, depressed stylopodia, simple leaves, and creeping stems. Several of these characters are not common outside of this group.

The stony endocarp of members of this group is not solely confined to it. Both *Heracleum* and *Pastinaca* (Figs. 32 & 33), equally strongly flattened in the opposite direction, are similarly equipped. To avoid leaving the impression that extreme flattening is always associated with a stony endocarp, it should be pointed out that a stony endocarp is known in some genera with little or no flattening while some with considerable flattening do not have a stony endocarp.

Subfamily Saniculoideae is represented here by *Sanicula* and *Eryngium*. They are indeed close as indicated by their similar displays of flowers, ornamented fruits, primary oil-tubes, circular disks around base of styles, long and persistent calyx-teeth, erect and recurved petals, and usually long-exserted styles and stamens. Several of these are worthy of discussion for clarification or because of their uniqueness.

The arrangement of the oil-tubes in the primary areas is unusual. Even the two large oil-tubes on the commissure are more widely spaced than is commonly

true of other Umbelliferae thereby placing them in the general positions of the lateral primary areas. This pattern holds true in all North Carolina representatives of the subfamily except in *Sanicula trifoliata*. It often has two large oil tubes marking the lateral primary regions, but the other three large ones are absent. In some species of *Sanicula* from other parts of the world, the tubes are often smaller and irregularly arranged.

The fruits of some species of *Sanicula* are pedicellate (Fig. 4), and strangely enough, these stalks split to their bases into two parts when the mericarps do. Unlike the pedicels of other Umbelliferae, they remain attached to the fruits when they shed, and their inner faces are continuous. This unusual condition suggests the possibility that the pedicels are really the contracted bases of the fruits. If this be the case, all fruits of *Sanicula* would be sessile just as they are in *Eryngium*.

Subfamily Apioideae contains the vast majority of genera and species. Hardly any single character is consistent throughout the group, yet their over-all appearance and similar structures indicate that they should be together. They usually have stylopodia, carpophores, primary ribs, and oil-tubes between the ribs. Probably the greatest variation from the majority is in *Daucus* and *Torilis*.

The lumping together of all species with extreme dorsal flattening does not seem to reflect their true origins. Some members have little in common except extreme flattening. It is more likely that this tendency had several origins. For example, the lateral wings of *Oxypolis* (Fig. 29) are not extensions of lateral ribs as appear to be the case in *Heracleum* and *Pastinaca*. The ribs are obviously dorsal to the wings (ribs usually described in the literature as nerved on the dorsal face). This new interpretation is based on the idea that strengthening cells are directly under true ribs and would hardly be expected off to the side. Certainly that is the position occupied in most, if not all, Umbelliferae. The distinctness of ribs and wings can be seen easily in sections of green fruits.

A possible clue of affinity should be sought elsewhere. It might be found in *Ptilimnium* or *Lilaeopsis*, for example. It is easy to visualize the cork cells between the two lateral ribs of some species of these genera proliferating into the lateral wings of *Oxypolis* since they occupy the same relative positions. The corky bands have been considered to be parts of the lateral ribs, but their position relative to the vascular traces and strengthening cells is usually distinctly toward the commissure (Figs. 27 & 28). For that reason, they are treated here as two distinct structures in the same way that the wings and ribs are treated in *Oxypolis*. They are regularly separate and uniform in *Ptilimnium capillaceum* and more irregularly separate and less uniform in *Lilaeopsis*. This fruit character is not the only point of similarity between *Oxypolis* and *Lilaeopsis*, for both genera have highly specialized representatives with phyllodes. On the other hand, striking differences may mean that these similarities are parallel developments.

Taenidia, *Thaspium*, and *Zizia* are closely linked by a combination of many similar features. They have regular flowers with yellow (one exception), erect, recurved petals and have fruits built on a similar plan. The apexes of the ovaries bear disks closely associated with the styles. Fruits in all three genera usually

have small oil-tubes outside the strengthening tissue in the ribs in addition to the regular larger ones. However, this characteristic is not wholly confined to these genera.

No less important is a consideration of the geographical distribution of these genera. When mapped, they all occupy regions overlapping in the eastern part of the United States. This is highly suggestive of a common line of origin somewhere in that area.

Pseudotaenidia appears to be close to this group, but because of a scarcity of material, a careful study was not possible. A striking point of difference from *Taenidia* is its dorsally flattened fruits. By taking the position that flattening arose in several places and at different times, it is easier to place it with *Taenidia* with which there is a striking resemblance. These two monotypic genera should be studied more carefully to confirm or deny this suggestion.

Another possible evidence for its being derived from *Taenidia* may be found in their geographical distributions. *Taenidia* ranges from Georgia to Texas and north to Quebec and Minnesota. The known range of *Pseudotaenidia* is from Virginia and West Virginia to Maryland and Pennsylvania. There is no known evidence that one is more fitted for survival than the other. It seems more likely that *Taenidia* is older and that *Pseudotaenidia* is younger and derived from it.

TAXONOMIC TREATMENT

Several terms need defining in order to interpret correctly what is to follow in the descriptions. The ovary, although inferior, is used here to describe the immature structure of the flower which will become the fruit. Petal length is the distance from the base to its outermost extent, either the tips or to where it recurves. When leaves are described as opposite the umbels, they may be normal or reduced, even bract-like.

Primary or secondary when used to describe a mericarp structure refers to its location. There are five primary and four secondary positions. Primary positions are on each side at the margin of the commissure (lateral), in the middle opposite the commissure (dorsal), and between the margins and the middle (intermediate). Secondary positions are between the primary ones.

Only one specimen from a county is cited and mapped. The word "county" and most given names or initials of collectors are omitted; either the collector's number or the date of the collection follows the name of the collector. Where several specimens are known from the same county, those at the University of North Carolina, Duke University, and North Carolina State College are given preference in that order. In other cases, specimens are generally cited which are duplicated in several herbaria. Personal collections from North Carolina have been deposited in the herbarium of the University of North Carolina; some duplicates elsewhere.

The maps usually have the largest number of symbols in North Carolina; in the majority of cases this indicates more intensive collecting rather than a greater density of population. If symbols on maps cannot be placed exactly where they should be, an arrow will indicate the direction from which they are displaced.

All range extensions beyond that given by Small or Mathias and Constance are indicated by the inclusion of the collector's name and number or date of collection in parenthesis following the location. This information is given in the treatment of each individual species under the discussion of distribution.

If any name differs from that found in Small's Manual, his name is listed as a synonym. Otherwise, synonyms are limited to a few well known ones. For a more complete listing of synonyms, refer to Mathias and Constance's monograph in *North American Flora* (1944–1945).

The symbols representing herbaria where cited specimens are deposited are as follows:

CLEMS	Clemson College
DUKE	Duke University
FLA	University of Florida
FUR	Furman University
GA	University of Georgia
GH	Gray Herbarium, Harvard
NCS	North Carolina State College
NCU	University of North Carolina
NY	New York Botanical Garden
PH	Philadelphia Academy of Natural Sciences
TENN	University of Tennessee
US	United States National Herbarium

FAMILY UMBELLIFERAE

Plants predominantly herbaceous. Stems erect or creeping, often hollow between the nodes. Leaves usually simple to decompound, sheathing at the base, and alternate. Inflorescences of umbels, heads, or proliferating umbels (flowers verticillate on axes). Flowers regular or somewhat radiant, mostly perfect or andromonoecious, and pentamerous except for bicarpellate pistil. Calyx-teeth absent to long and persistent, usually small. Petals erect or spreading, straight or recurved at the tips. Stamens alternate with petals; anthers versatile. Styles arising from the top of a glandular structure (stylopodium) or encircled by a glandular disk at their base. Ovary inferior, two-chambered; each chamber with a single anatropous ovule. Fruit a schizocarp with two parts (mericarps) and terete to extremely flattened (dorsally, if parallel to plane of commissure; laterally, if at right angles to plane of commissure). Mericarps usually with five primary ribs or wings and sometimes with four secondary ones; mericarps may be covered with bristles or scales, and ribs may be obscure. Carpophore present or absent, entire to split to base. Oil-tubes usually present in pericarp, especially between ribs. Seed smooth or furrowed, endosperm abundant, embryo small.

Although cosmopolitan, the Umbelliferae are most abundant in north temperate regions and scarce in the tropics except in the mountains. The name Umbelliferae was first applied to this family by A. L. de Jussieu in *Genera Plantarum* in 1789. Willis (1948) estimates that there are two hundred genera and twenty seven hundred species in the family.

KEY TO THE UMBELLIFERAE OF NORTH CAROLINA

1. All leaves simple 2
   Some leaves compound 9
2. Stems creeping, sometimes weakly ascending 3
   Stems erect 6
3. Leaves with blades less than five times as long as wide, rarely more, rarely entire 4
   Leaves elongate, many times longer than wide, always entire (leaves actually septate phyllodes) ..... 29. *Lilaeopsis*
4. Leaves peltate or if not peltate, bases cordate to almost truncate; petals not recurved at tips; stamens and styles about equal or shorter than petals; ovary and fruit strongly laterally flattened 5
   Leaves not peltate, bases tapering or palmately lobed or leaves pinnatifid; petals recurved at tips; stamens and styles much longer than petals; ovary and fruit slightly flattened or terete ..... 3. *Eryngium*
5. Leaf blades ovate to oblong; flowers or fruits in inflorescence usually 2 or 3, rarely 4, subtended by 2 conspicuous bracts ..... 2. *Centella erecta*
   Leaf blades round to reniform; flowers or fruits in inflorescence 1 to many, each subtended by a bract ..... 1. *Hydrocotyle*
6. Leaves terete (rush-like); if not terete, some perfoliate 7
   Leaves with blades, but not perfoliate 8
7. Leaves terete; flowers white; fruits dorsally flattened ..... 30. *Oxypolis*
   Leaves perfoliate or clasping; flowers yellow; fruits somewhat laterally flattened 16. *Bupleurum rotundifolium*
8. Inflorescence of heads; ovary and fruit with hyaline scales or tubercles ..... 3. *Eryngium*
   Inflorescence of umbels; ovary and fruit without scales or tubercles 30. *Oxypolis ternata*
9. Inflorescence of distinct heads or of umbels so compacted that they appear capitate (if inflorescence a compacted umbel, plants are hispid) 10
   Inflorescence of distinct umbels or if reduced and somewhat "head-like," usually containing 3 perfect flowers or fruits and 0 to many staminate flowers (if inflorescence somewhat "head-like," plants are always without pubescence) 11
10. Plants glabrous; ovaries and fruits with hyaline scales or tubercles ..... 3. *Eryngium*
    Plants hispid; outer part of ovaries and fruits with bristles ..... 6. *Torilis nodosa*
11. Ovary and fruit with pubescence, tubercles, bristles, or teeth 12
    Ovary and fruit smooth or with ribs or wings 21
12. Ovary about twice as long as wide or longer; fruit obviously over twice as long as wide 13
    Ovary less than twice as long as wide; fruit less than twice as long as wide to about twice as long as wide 14
13. Leaves with first divisions ternate; ovary and fruit narrowed at base ..... 8. *Osmorhiza*
    Leaves pinnately decompound; ovary and fruit with a beak at apex several times longer than the body ..... 7. *Scandix pecten-veneris*
14. Leaves compound, palmately 3- or 5-foliate, rarely 7-foliate 15
    Leaves decompound 16
15. Plants wooly; petioles of upper leaves conspicuously "inflated," wooly; ovary and fruit pubescent; flowers irregular ..... 33. *Heracleum lanatum*
    Plants glabrous or glaucous; petioles of upper leaves not conspicuously "inflated"; ovary and fruit with bristles; flowers regular ..... 4. *Sanicula*
16. Leaf blades broad, thickish; ovary and fruit pubescent; mature fruit strongly dorsally flattened; petioles of upper leaves "inflated" and their blades reduced or absent 31. *Angelica venenosa*
    Leaf blades dissected; ovary and fruit with teeth, tubercles, bristles, or minute pubescence; mature fruit laterally flattened or terete; petioles of upper leaves not strongly "inflated" 17

17. Plants glabrous; ovary and fruit tuberculate..................18
Plants hispid to weakly pubescent, rarely glabrous; ovary and fruit with teeth, bristles, or minute pubescence..................19
18. Stem spotted; plant with strong offensive odor; petals unequal, recurved at tips; all flowers and fruits pedicellate..................12. *Conium maculatum*
Stem not spotted; plant without strong offensive odor; petals about equal, not recurved at tips; central flower and fruit in many umbelets sessile or short pedicellate
23. *Spermolepis divaricata*
19. Ovary and fruit with teeth or bristles; flowers, especially outside ones, somewhat or distinctly irregular; petals white, pink, or purple; fruit with bristles or teeth....20
Ovary and fruit minutely pubescent; flowers regular; petals yellow; fruit with shallow wings..................18. *Thaspium pinnatifidum*
20. Bracts mostly pinnate or pinnately decompound, sometimes 3-parted or rarely simple; bractlets simple to pinnate; teeth of fruit usually much flattened, in simple rows
5. *Daucus*
Bracts absent or simple and narrow; bractlets subulate, sometimes acute; bristles of fruit glochidiate, not in simple rows..................6. *Torilis japonica*
21. Lower leaf or leaves trifoliate, bifoliate, or simple; most other leaves trifoliate or simpler..................22
Lower leaf or leaves with more than three blades; most other leaves trifoliate or more compound, sometimes all leaves dissected..................27
22. Basal leaf or leaves simple, cordate; stem leaves usually like the basal ones or trifoliate..................23
Basal leaf or leaves trifoliate or simpler, if simple, not cordate; stem leaves usually like the basal ones, but may be more compound..................24
23. Perfect flowers and fruits when present in center of umbelets always sessile or subsessile; ribs of fruit filiform, not winged..................19. *Zizia aptera*
All flowers or fruits on distinct pedicels; ribs of fruits winged..................18. *Thaspium*
24. Plants wooly; petioles of upper stem leaves conspicuously "inflated" and wooly; flowers irregular..................33. *Heracleum lanatum*
Plants glabrous or pubescent (not wooly); petioles of upper stem leaves neither "inflated" nor wooly; flowers regular or nearly so..................25
25. Leaf blades long and slender (many times longer than wide); roots tuberous, club-shaped or obovoid; fruits dorsally flattened..................30. *Oxypolis ternata*
Leaf blades broad; roots fibrous or fleshy, but not broadest at distal end; fruits laterally flattened or terete..................26
26. Terminal leaflets tapering and serrate at base; fruit twice as long as wide or longer; umbels distinctly asymmetrical because rays (1–6) and pedicels very unequal; flowers white; all leaves trifoliate..................10. *Cryptotaenia canadensis*
Terminal leaflets tapering, truncate, or cordate, but not serrate at base; fruit less than twice as long as wide; umbels symmetrical, rays 3–16; flowers yellow or purple; leaves all trifoliate or trifoliate to decompound..................(go back to 23)
27. Blades of upper or all stem leaves much dissected..................28
Blades of upper or all stem leaves broad, if narrow, not dissected; upper leaves may be considerably reduced..................39
28. Ultimate divisions of upper leaves filiform or linear..................29
Ultimate divisions of upper leaves broader..................34
29. Umbels simple, 1–3 at a node or compound with 1–3 rays; some center flowers and fruits sessile or subsessile; petals not recurved at tips....24. *Apium leptophyllum*
Umbels compound, mostly over 3-rayed; center flowers and fruits of umbelets distinctly pedicellate; petals recurved at tips..................30
30. Bracts and rays arising from a disk; bractlets and pedicels arising from smaller disks
25. *Ammi visnago*
Bracts absent or if present, they and rays not arising from a disk; bractlets absent or if present, they and pedicels not arising from disks..................31

31. All leaves decompound; flowers regular or nearly so; ribs of fruit not wavy; fruits flattened or almost globose (if globose, mericarps separate easily), flattened fruits longer than wide and tending to split apart at maturity........................32
Lower leaves simple, ternate, or pinnate and having broad blades with coarse teeth or lobes; flowers irregular; radiant petals deeply bilobed and with obvious branching veins; ribs filiform, straight ones alternate with wavy ones; fruit globose, mericarps not separating easily at maturity.........................11. *Coriandrum sativum*
32. Bracts and bractlets absent; flowers yellow; plant with strong anise odor; perennial 14. *Foeniculum vulgare*
Bracts and bractlets present or sometimes absent; flowers white or rarely rose-colored; plant with no odor of anise; biennial or annual.................................33
33. Umbels very asymmetrical, the rays and pedicels very unequal; taproots; fruits without band of cork at the commissure, more than twice as long as wide....20. *Carum carvi*
Umbels symmetrical; roots fibrous; fruits with a band of cork at the commissure, less than twice as long as wide.......................................28. *Ptilimnium*
34. Ovary and fruit twice as long as wide or longer..................9. *Chaerophyllum*
Ovary and fruit less than twice as long as wide...............................35
35. Plants small, less than 20 cm. tall, and arising from deep, globular tubers; petals not recurved at tips; leaves mostly 1-3 (occasionally 4); umbels with 1-4 rays; bractlets spatulate..13. *Erigenia bulbosa*
Plants larger, much more than 20 cm. tall, not arising from globular tubers; petals recurved at tips; leaves usually several to many more than four; umbels usually with well over 4 rays; bractlets not spatulate.............................36
36. Stem spotted; plant with strong offensive odor...............12. *Conium maculatum*
Stem not spotted; plant without strong offensive odor.............................37
37. Petioles of upper leaves "inflated", more conspicuous than their reduced blades; petals white; some flowers irregular; fruit much dorsally flattened 32. *Conioselinum chinense*
Petioles of upper leaves not "inflated"; petals yellow; flowers regular; fruit laterally flattened or slightly dorsally flattened.....................................38
38. Bractlets with hyaline margins; fruit laterally flattened, not winged; blades of upper leaves with narrow divisions.....................................15. *Petroselinum*
Bractlets without hyaline margins; fruit terete or slightly flattened, winged; blades of upper leaves broad, coarsely toothed or incised.........18. *Thaspium barbinode*
39. Leaves mostly pinnate (usually 7 or more leaflets; all leaflets except terminal one sessile or on short petiolules)...40
Leaves mostly pinnately or ternately decompound (upper leaves may be simpler), if pinnate, leaflets usually fewer than 7, with lower leaflets larger and stalked and those at apexes of leaves smaller and sessile..............................42
40. Blades of leaflets entire or with a few large teeth concentrated toward tips or along one side..30. *Oxypolis rigidior*
Blades of leaflets never entire; teeth numerous and extending almost completely around margin...41
41. Blades of leaflets coarsely and irregularly serrate, often variously cut; lower leaves never pinnately dissected; flowers yellow; fruit dorsally flattened 34. *Pastinaca sativa*
Blades of leaflets sharply and uniformly serrate; lower leaves sometimes pinnately dissected; flowers white; fruit laterally flattened....................26. *Sium suave*
42. Leaflets entire..17. *Taenidia integerrima*
Leaflets not entire...43
43. Many umbels sessile or nearly so; basal leaves pinnate-ternate or bipinnate 24. *Apium graveolens*
Umbels pedunculate, rarely sessile; basal leaves variable, but not pinnate-ternate..44
44. Petioles of upper leaves "inflated", more conspicuous than their reduced blades (sometimes blades absent); fruit much dorsally flattened...............................45

Petioles of upper leaves not "inflated", less conspicuous than their blades; fruit laterally flattened or obscurely dorsally flattened (if dorsally flattened, some ribs are winged) 46

45. Leaves pinnate or bipinnate; leaflets obtuse to acute; flowers yellow; bractlets usually absent or if present, few .... 34. *Pastinaca sativa*

Leaves usually 2-or 3-ternate or ternate-pinnate; leaflets usually acuminate; flowers greenish; bractlets always present (6–12)........................ 31. *Angelica triquinata*

46. Branches bearing umbels usually opposite or whorled; leaves on these branches very reduced or bract-like; umbels usually several to many and arranged in a simple or compound cyme; stem very brittle; root with the odor of celery and bearing a crown of fibers .... 21. *Ligusticum canadense*

Branches bearing umbels usually solitary or absent, if opposite or whorled, branches usually leafy; umbels opposite leaves or cymose, if cymose, leaves on branches not bract-like; stems not unusually brittle; root neither with odor of celery nor having a fibrous crown 47

47. Perfect flowers or fruits when present in center of umbelets always sessile or subsessile 19. *Zizia*

All flowers or fruits distinctly pedicellate 48

48. Flowers white; ribs of fruit not extended as wings 49

Flowers yellow; some ribs of fruit extended as wings......... 18. *Thaspium barbinode*

49. Leaves not variegated; veins of leaves usually ending near notches between the teeth or approaching them closely before branching toward teeth; petioles without hyaline-margined sheaths .... 27. *Cicuta*

Leaves variegated; veins extending to teeth; petioles with hyaline-margined sheaths 22. *Aegopodium podagraria* var. *variegatum*

1. HYDROCOTYLE L. Marsh Pennyworts, Water Pennyworts, Navelworts

Mostly glabrous, creeping or floating perennials. Roots fibrous, from the nodes. Leaves simple, peltate, cordate, or reniform, one to a node; blades crenate, shallowly lobed, dentate, or entire. Inflorescences variable. Flowers regular, perfect, few to many. Calyx-teeth obsolete. Petals greenish or white, sometimes tinged with rose, spreading, not recurved at tips. Stamens and styles shorter than petals, maturing at about the same time. Stylopodium depressed. Ovary smooth, strongly laterally flattened. Fruit strongly laterally flattened, as broad or broader than tall; ribs primary. Carpophore absent. Oil-tubes absent; oil-cells usually present. Endocarp usually stony. Seed laterally flattened.

Leaves peltate.

Inflorescence of simple umbels, rarely weakly proliferous .... 1. *H. umbellata*

Inflorescence of whorls of flowers or fruits at intervals along a single, bifurcating, or more extensively branched rachis.

Inflorescence with a single or bifurcating rachis.

Flowers and fruits sessile or subsessile.............................. 2. *H. verticillata*

Flowers and fruits pedicellate...................... 2a. *H. verticillata* var. *triradiata*

Inflorescence branching into a dendritic pattern at maturity, these branches being simple, bifurcating, or whorled.. 3. *H. bonariensis*

Leaves not peltate.

Leaf blades with a distinct terminal lobe, clefts extending approximately ½ distance from margin to petiole attachment .... 4. *H. ranunculoides*

Leaf blades not deeply lobed; lateral lobes cut about same depth as terminal one.

Peduncles absent or short, rarely up to 2 cm., much shorter than petioles of same node; only one leaf from a node; flowers and fruits on short pedicels; mature leaves usually over 13 mm. broad.. 5. *H. americana*

Peduncles always distinct, at maturity about equaling or exceeding petioles of same node; some nodes with more than one leaf; flowers and fruits sessile or subsessile; mature leaves less than 13 mm. broad .... 6. *H. sibthorpioides*

1. *Hydrocotyle umbellata* L. Marsh Pennywort, Water Navelwort, Umbellate Marsh Pennywort.

Leaves shallowly lobed, dentate, or crenate; umbels subequal or exceeding the leaves; flowers 30–50 to an umbel; fruit (Fig. 1) 2–3 mm. wide and 1–2 mm. high, shallowly cordate at base; lateral and dorsal ribs very corky, intermediates much narrower; mericarps widest at commissure and narrow at outer edge.—Native. Flowers from spring to fall.

DISTRIBUTION: Low places, pools, ditches, and stream banks; chiefly on coastal plain. Fla. to Tex., north to N. S. and Minn.; Calif. and Ore.; C. A., S. A., and old World; in Southeast (Map I), known or reported from every state.

SPECIMENS CITED: ALABAMA: Autauga, Smith, Aug. 18, 1897 (US); Baldwin, Schallert 514 (DUKE); Mobile, Mackenzie 4045 (NY). FLORIDA: Alachua, Miller, 415 (US); Brevard, Fredholm 5918 (GH); Bradford, West & Arnold, May 15, 1940 (FLA); Broward, Small & Carter 1161 (NY, PH); Citrus, West & Arnold, May 15, 1940 (FLA); Clay, Moldenke 5238 (NY); Columbia, Rolfs 146 (FLA); Dade, Small & Carter 2636 (NY); De Soto, Small 8190 (FLA, NY); Duval, Moldenke 173a (DUKE); Escambia, Collins, May 12, 1917 (GH); Flagler, West & Arnold, April 18, 1940 (FLA); Franklin, McAtee 1717 (US); Gilchrist, Hixon, Arnold, & West, Aug. 15, 1944 (FLA); Hamilton, West & Arnold, Sept. 30, 1941 (FLA); Hernando, Jones 62 (US); Highlands, McFarlin 10143 (FLA); Hillsborough, Barnard 2222 (NY); Jefferson, Spurry 523 (US); Lafayette, West & Arnold, May 20, 1940 (FLA); Lake, Nash 351 (GH, PH, US); Lee, Hitchcock 128 (US), 129 (GH); Leon, Moldenke 1115 (DUKE, NY); Marion, West & Arnold, May 27, 1940 (FLA); Orange, Walker 1762 (PH); Osceola, Singeltary 186 (DUKE, NCS); Palm Beach, Randolph 186 (GH); Pasco, O'Neill 8182 (US); Polk, Milligan, March, 1888 (US); Putnam, Laessle, April 21, 1940 (FLA); Sarasota, Smith, March 2, 1904 (DUKE); St. Lucie, Small et al. 9288 (NY); Volusia, Straub 142 (GH). GEORGIA: Charlton, Harper 1471 (GH, NY, US); Chatham, Eyles 1817 (DUKE); Glynn, Leeds 2823 (PH); Richmond, Cuthbert, May, 1881 (FLA); Screven, Eyles 7566 (GA). LOUISIANA: Avoyelles, McAtee 2220 (US); East Baton Rouge, collector unknown, June, 1858 (NY); Feliciana (East or West?), Carpenter, 1840 (US); Lafayette, Claycomb, July 8, 1942 (GH); Rapides, Hale, no number or date (NY, PH); Saint Tammany, collector unknown, Nov. 16, 1894 (US). MISSISSIPPI: Harrison, Baker 788 (PH), 779 (NY); Jackson, Seymour 919941 (DUKE, GH, NCU). NORTH CAROLINA: Beaufort, Rodgers 354C (NCU); Bladen, Blomquist 4400 (DUKE); Brunswick, Rodgers 289C (NCU); Carteret, Rodgers 857C (NCU); Chowan, Rodgers 558C (NCS, NCU); Columbus, Wiegand & Manning 2275 (GH); Craven, Correll 1466 (DUKE); Currituck, Rodgers 533C (NCU);

Dare, Rodgers 527C (NCU); Greene, Correll 1343 (DUKE); Harnett, Oosting 1914 (DUKE); Hoke, Rodgers 573C (NCU); Hyde, Mathews, 1931 (NCU); Martin, Rodgers 501C (NCU); Moore, Oosting 33742 (DUKE); New Hanover, Rodgers 304C (NCU); Onslow, Rodgers 865C (NCU); Pamlico, Rodgers 352C (NCU); Pasquotank, Oosting 35501 (DUKE); Pender, Rodgers 866C (NCU); Perquimans, Rodgers 548C (NCU); Pitt, Rodgers 493C (NCU), Sampson, Godfrey, June 11, 1938 (DUKE); Scotland, Godfrey 5085 (DUKE, GH); Tyrrell, Rodgers 512C (NCU); Wake, Ashe, Aug., 1897 (NCU); Wayne, Rodgers 202AC (GH, NCU). SOUTH CAROLINA: Aiken, Radford 542 (NCU); Beaufort, Cuthbert, May, 1899 (FLA); Berkeley, Hunt 8806 (CLEMS); Charleston, Godfrey & Tryon 1101 (GH, NY); Clarendon, Stone 689 (PH); Darlington, Smith 1600 (NCU); Georgetown, Raynal, Sept. 20, 1937 (NCU); Horry, Coker, July 31, 1945 (NCU); Lexington, McGregor 180 (US). TENNESSEE: Reported from Davidson County by Gattinger.

2. *Hydrocotyle verticillata* Thunb. Whorled Marsh Pennywort.

Leaves crenate to almost entire; inflorescence with 3–7 nodes; flowers and fruits 2–7 to a node; fruit 2–4 mm. wide and 1–3 mm. high, cuneate or almost truncate at base; lateral and dorsal ribs very corky, intermediates narrow; mericarps widest at commissure and acute on outer edge.—Native. Flowers from spring to fall.

DISTRIBUTION: Wet places, particularly in mud; coastal plain. Tex. and Mo., east to Fla. and up the coast to Mass.; from Tex. westward to Utah, Calif., and Ore.; in Southeast (Map II), all states except Tenn.

SPECIMENS CITED: ALABAMA: Autauga, Svenson & Harper 9489 (GH); Escambia (?), Eggert, July 9, 1898 (NY); Houston, Wiegand & Manning 2280 (GH); Lee, Earle & Baker, July 8, 1897 (NY); Mobile, Mohr, no number or date (US). FLORIDA: Alachua, Arnold, April 7, 1932 (FLA); Brevard, Fredholm 6210 (GH, NY); Broward, Bush 86 (NY); Citrus, Murrill, June 6, 1941 (FLA); Clay, Canby, March, 1868 (US), March, 1869 (GH, NY, PH); Columbia, Nash 2485 (FLA, GH, NCU, PH, US); Dade, Elder 440 (DUKE); De Soto, Small 8175 (NY); Duval, Curtiss 4963 (GH, US); Jackson, Bush 88 (NY); Lee, Hitchcock 126 (GH, US); Manatee, Tracy 6837 (GH, NY, US); Monroe, Small & DeWinkeler, April 28, 1921 (DUKE, FLA); Orange, Fredholm 5364 (GH); Palm Beach, Curtiss 5377 (GH); Pinellas, Williams, Feb. 16, 1926 (PH); Putnam, Curtiss 992 (US); Sarasota, Moldenke 5918 (NY); St Johns, Reynolds, 1877 (NY); Union, West & Arnold, May 22, 1942 (FLA); Volusia, Arnold, May 1, 1934 (FLA). GEORGIA: Baldwin, Short, no number or date (PH); Bibb, collector and date unknown (PH); Camden, Wiegand & Manning 2279 (GH); Clay, Harper 1789 (NY, US); Glascock, Harper 1323 (GH, NY, US); Houston, Ainsworth 446047 (PH); Jasper, collector and date unknown (PH); Miller, Thorne 6382 (US); Richmond, Cuthbert, 1903 (FLA). LOUISIANA: Bossier, Correll 10254 (DUKE); Calcasieu, MacKensie 520 (NCU, NY); Livingston, Correll 1971 (DUKE); Orleans, Purly (?), Feb. 10, 1910 (NY); Rapides, Hale, no number or date (PH); Saint

Tammany, Arsene 11417 (US). MISSISSIPPI: Harrison, Tracy 4471 (US). NORTH CAROLINA: Bladen, Biltmore Herbarium 2542a (GH, NY, US); Brunswick, Rodgers 314C (NCU); Camden, Rodgers 540C (NCU); Carteret, collector and date unknown (NY); Columbus, Rodgers 880C (NCU); Craven, Rodgers 341AC (NCU); Currituck, Rodgers 535C (NCU); Duplin, Rodgers 876C (NCU); Edgecombe, Rodgers 568C (NCU); Greene, Rodgers 846C (NCU); Lenoir, Rodgers 847C (NCU); New Hanover, collector and date unknown (NY); Pasquotank, Rodgers 543C (NCU); Perquimans, Rodgers 551C (NCU); Sampson, Rodgers 878C (NCU); Tyrrell, Rodgers 517C (NCU). SOUTH CAROLINA: Aiken, Ravenel, no number or date (US); Beaufort, Mellichamp 1179 (US); Berkeley, Godfrey & Tryon 627 (GH, NY), 628 (US); Charleston, Hexamer & Maier, May 17, 1855 (GH); Darlington, Smith 1470 (NCU); Williamsburg, Godfrey & Tryon 533 (DUKE, GH, NY, PH, US). TENNESSEE: None.

2a. *Hydrocotyle verticillata* var. *triradiata* (A. Rich) Fern. (*H. canbyi* C. & R.; *H. australis* C. & R.) Canby's Marsh Pennywort or Water-cup.

Inflorescences with 3–4 nodes; pedicels 1–10 mm. long, 4–15 to a node; fruit about 4 mm. wide and 2–2.5 mm. high, shallowly cordate at base and apex; lateral and dorsal ribs acute, very corky, intermediates much narrower; mericarps widest at commissure and narrow at outer edge.—Native. Flowers from spring to fall.

DISTRIBUTION: Wet places, mud or sand; coastal plain. Fla. north to Mass., Fla. west to Texas, Nev., and Calif.; south to S. A.; in Southeast (Map II), all coastal states except Ala. (probably present there, also).

SPECIMENS CITED: ALABAMA: None. FLORIDA: Alachua, West, April 26, 1935 (FLA); Dade, Small 8066 (NCU); Duval, Curtiss 922 (FLA, PH, US); Escambia, Macfarlane & Goertz, June 17, 1905 (DUKE); Hillsborough, Williamson, Aug., 1894 (PH); Palm Beach, Curtiss 5376 (FLA, GH, NY); St. Johns, Reynolds, 1877 (PH). GEORGIA: Thomas, Small, May 28–June 6, 1895 (NY). LOUISIANA: Jefferson, Ball 354 (GH, NY); Orleans, Moore, no number or date (NY). MISSISSIPPI: Label illegible, March, 1874 (GH). NORTH CAROLINA: Beaufort, Rodgers 354C (NCU); Brunswick, Rodgers 281C (NCU); Camden, Rodgers 536C (NCU); Carteret, Godfrey, Fox, & Blomquist 49571 (NCS); Chowan, Rodgers 554C (NCU); Craven, Rodgers 339AC (NCU); Currituck, Godfrey & Fox, June 10, 1949 (NCS); Dare, Rodgers 524C (NCU); Edgecombe, Rodgers 490C (NCU); Hyde, Ashe, June 16, 1898 (NCU); Jones, Rodgers 344C (GA, NCU); Martin, Rodgers 500C (NCU); Onslow, Rodgers 874C (NCU); Pamlico, Rodgers 346AC (NCU); Perquimans, Rodgers 553C (NCU); Pitt, Rodgers 492C (NCU); Washington, Rodgers 508C (NCU). SOUTH CAROLINA: Beaufort, Cuthbert, no number or date (FLA); Charleston, Hunt 228 (CLEMS); Horry, Coker, July 31, 1945 (NCU); Sumter, Stone, May 25, 1914 (PH). TENNESSEE: None.

3. *Hydrocotyle bonariensis* Lam.

Leaves shallowly dentate or crenate-dentate, surface appearing roughish when old; umbels exceeding leaves in length; fruit about 3 mm. wide and 2 mm. high, cordate at base; lateral and dorsal ribs very corky, intermediates much narrower; medicarps widest at commissure and narrow at outer edge.

DISTRIBUTION: Sandy places, wet or dry, near the coast. Fla. to N. C. and Tex.; south to S. A.; in Southeast (Map I), every coastal state.

SPECIMENS CITED: ALABAMA: Mobile, Howell 750 (US). FLORIDA: Bay, Martin 1661 (DUKE); De Soto, Schallert, July 29, 1950 (GH); Duval, Small 9695 (NY); Escambia, Curtiss 5922 (FLA, GH, NCU, NY, US); Franklin, Moldenke 1149 (NY); Gulf, Moldenke 1147 (DUKE); Lee, Eaton 1417 (GH); Manatee, Correll 5878 (DUKE, GH); Nassau, West & Small, Aug. 9, 1935 (FLA); Okaloosa, Hickernell, March 15, 1949 (FLA); St. Johns, Browne A-32 (NCU); Santa Rosa, Fassett 19865 (NY); Volusia, Rau (?), March, 1919 (PH); Walton, Curtiss, summer, 1885 (NY). GEORGIA: Glynn, Cronquist 5360 (FLA, GH, US). LOUISIANA: Jefferson, Andrews 2 (NY); Plaquemines, Langlois 50 (US). MISSISSIPPI: Hancock, Browne A-51 (NCU); Harrison, Pollard 1153 (GH, NY, US); Jackson, Tracy 6390 (GH, NY, US). NORTH CAROLINA: Brunswick, Rodgers 323C (NCU); Carteret, Ulmer, July 9, 1947 (DUKE); Hyde, Mathews, summer, 1931 (NCU); New Hanover, Biltmore Herb. 5708 (US); Pamlico, Rodgers 351C (NCU). SOUTH CAROLINA: Charleston, Schallert 1651 (DUKE); Horry, Coker & Totten, July 12, 1932 (NCU). TENNESSEE: None.

4. *Hydrocotyle ranunculoides* L. f. Floating Marsh Pennywort.

Plants floating or creeping; leaves with distinct lobes; inflorescences opposite leaves and much shorter (2.5–6.5 cm. long), tending to recurve, 5–10 pedicellate flowers or fruits to umbel; petals greenish; fruit with cordate base, broader than apex, not corky; oil-cells scattered, not in a layer.—Native. Flowers from spring to fall.

DISTRIBUTION: Pools, ditches, swamps, and wet banks; coastal plain and up Miss. River Valley. Tex. and Ariz., up east coast to Penn. and west coast to Wash.; S. A. and Old World; in Southeast (Map I), all states (reported in Tenn.).

SPECIMENS CITED: ALABAMA: Mobile, Baker, March 18, 1897 (PH). FLORIDA: Franklin, Curtiss 5886 (FLA, GH, NCU, US). GEORGIA: CHATHAM, Smith 407 (US). LOUISIANA: Orleans,—(illegible), 1935 (NY); Rapides, Hale, no number or date (PH). MISSISSIPPI: Leflore, Barber, May 27, 1925 (DUKE). NORTH CAROLINA: Chowan, Kearney 1908 (US); Currituck, reported by McAtee on Church's Island; Dare, Rodgers 528C (DUKE, GA, NCS, NCU, NY); New Hanover, Godfrey & Wells 4309 (GH, NCS, US). SOUTH CAROLINA: BERKELEY, Hunt & Martin 1525 (CLEMS). TENNESSEE: Coffee, reported by Gattinger.

5. *Hydrocotyle americana* L. American Pennywort, Penny-post, Marsh Pennywort.

Slender creepers; tuberous; leaves thin, shallowly lobed, lobes with 3–8 crenations; petals greenish; fruit about 1.75 mm. broad and 1.25 mm. tall, cordate at base; ribs filiform.—Native. Flowers from spring to fall.

DISTRIBUTION: Swamps, stream banks, and low woods; mts. of this state. N. C. to Newf., west to Wis.; in Southeast (Map I), N. C. and Tenn., reported from S. C.; specimen labeled Polk Co., Fla., is probably an error.

SPECIMENS CITED: NORTH CAROLINA: Buncombe, Biltmore Herb. 4003a (GH, NY, US); Macon, Rodgers 604C (DUKE, GA, NCS, NCU, US); Transylvania, Rodgers 635C (GA, NCS, NCU), 634C (NCU). (SOUTH CAROLINA: Reported by Ives and Coulter.) TENNESSEE: Polk, reported by Gattinger; Van Buren, J. K. U. & Sharp, July 19, 1935 (PH). FLORIDA: Polk, McFarlin, 1925 (FLA), probably an error in location.

6. *Hydrocotyle sibthorpioides* Lam. (*H. rotundifolia* Roxb.) Asiatic Pennywort, Lawn Pennywort.

Small, delicate creepers; leaves thin, lobed, each lobe with 3 crenations; fruit about 1–1.5 mm. broad and tall, ribs filiform.—Introduced weed. Flowers from spring to fall.

Mrs. W. B. Ward sent a specimen from her lawn at Concord to North Carolina State College. Since then collections have been made from along the paths in Duke University Garden and from the Duke Hospital lawn. It will probably be seen more often in the future. Hansen (1921) reports that it becomes a nuisance on lawns and golf courses.

DISTRIBUTION: Lawns, flower gardens, golf courses, and greenhouses. Known from La., Ga., N. C., D. C., Penn., Ky., and Ind.; in Southeast (Map I).

SPECIMENS CITED: GEORGIA: Richmond, (greenhouse), Cuthbert, no number or date (FLA). LOUISIANA: Orleans, Pennell 10183 (NY). NORTH CAROLINA: Cabarrus, Ward, Oct. 14, 1946 (NCS); Durham, Rodgers 893C & 900 (NCU).

2. CENTELLA L.

Glabrous to densely arachnoid perennials. Roots from nodes, fibrous. Leaves simple, palmately-veined, petiolate. Flowers regular, perfect. Calyx-teeth absent. Petals white or greenish, often tinged with rose, spreading, not recurved at tips. Stamens and styles shorter than petals. Stylopodium depressed. Ovary and fruit strongly laterally flattened; fruit (Fig. 2) with primary ribs, secondary ribs, and reticulations. Carpophore not distinct. Endocarp stony. Oil-tubes mostly absent. Seed laterally flattened.

1. *Centella erecta* (L. f.) Fern. (*C. asiatica* [L.] Urban; *C. repanda* [Pers.] Small) Ovate-leaved Pennywort, Ovate-leaved Marsh Pennywort, Intelligence Plant, Ovate Water-cup.

Plants slender, creeping; 1–7 leaves from each node; leaves ovate to oblong, apexes rounded, bases cordate or truncate, margins entire, sinuate, or dentate; inflorescences 1–5 from a node, usually much shorter than petioles from the same node; flowers 1–4, usually 3 in each inflorescence, pedicellate to nearly sessile; petals triangular and widely spaced, usually some pubescence on the under surface; anthers purple; fruit broader than tall; oil-layer below epidermis. —Native. Flowers from spring to fall.

DISTRIBUTION: Low moist places; coastal plain. Coastal states from Tex. to Del. and Md.; on ballast in Ore.; Mex., S. A., and Old World; in Southeast (Map II), every state except Tenn.

SPECIMENS CITED: ALABAMA: Lee, Tracy 6682 (NY); Mobile, Mohr, July, 1879 (US). FLORIDA: Alachua, Kelbert & West 86 (FLA); Baker, West & Arnold, April 25, 1940 (FLA); Bradford, West & Arnold, May 15, 1940 (FLA); Broward, Moldenke 592 (DUKE, NY); Citrus, West & Arnold, June 24, 1941 (FLA); Clay, Martin, April 15, 1885 (PH); Dade, Small 8053 (NCU); Dixie, Pasture Survey, Aug. 11, 1937 (FLA); Duval, Curtiss 988 (FLA, GH, PH); Escambia, Macfarlane, June 17, 1905 (DUKE); Flagler, West & Arnold, April 18, 1940 (FLA); Franklin, Biltmore Herbarium 4004C (GH, NY, US); Gilchrist, DeVall & Arnold, May 18, 1940 (FLA); Glades, Lovett 267 (DUKE); Hamilton, West & Arnold, Sept. 30, 1941 (FLA); Hardee, Kirk, July 8, 1942 (FLA); Hillsborough, Garber, May, 1878 (US); Jefferson, Exploration Party, March 16, 1939 (FLA); Lake, Nash 1031 (GH, PH, US); Lee, Standley 118 (HG, PH, US); Leon, Crevasse, Aug. 16, 1940 (FLA); Levy, Pasture Survey, Aug. 20, 1937 (FLA); Marion, West & Arnold, May 15, 1940 (FLA); Nassau, West & Arnold, June 3, 1942 (FLA); Osceola, Singeltary 229 (DUKE, NCS); Palm Beach, Randolph 41 (GH); Polk, Smith, March, 1879 (US); Putnam, Curtiss 922 (US); Saint Johns, Curtiss 6228 (FLA, NCU); Sumter, Scott, Dec. 22, 1933 (DUKE); Union, West & Arnold, May 22, 1942 (FLA); Volusia, Hood, March, 1912 (FLA). GEORGIA: Berrien, Lemon, Oct. 30, 1940 (FLA); Camden, Biltmore Herbarium 4004e (PH); Charlton, Harper 193 (PH); Chatham, Crawford, July 25, 1923 (PH); Colquitt, Harper 1942 (GH, NY, US); Glynn, Lee, March 28, 1914 (NY); McIntosh, Small, June 25–27, 1895 (NY); Sumter, Harper, July 27, 1897 (NY); Ware, Meyell 255 (PH); Worth, Svenson 6953 (GH). LOUISIANA: Calcasieu, Mackensie 521 (NCU); Orleans, collector and date unknown (GH). MISSISSIPPI: Harrison, Tracy, Earle, & Seymour 919521 (DUKE, NCU); Jackson, Seymour 919237a (DUKE). NORTH CAROLINA: Brunswick, Rodgers 320C (NCU); Carteret, Rodgers 854C (NCS, NCU); Columbus, Rodgers 336C (NCU); Craven, Rodgers 852C (NCU); Currituck, Rodgers 534C (NCU); Dare, Rodgers 523C (NCU); Hyde, Rodgers 519C (NCU); New Hanover, Rodgers 3[illegible]C (NCU); Onslow, Rodgers 862C (NCU); Pamlico,

Rodgers 344AC (DUKE, NCU); Robeson, Rodgers 879C (NCU); Tyrrell, Rodgers 509C (NCU); Washington, Rodgers 506C (NCU). SOUTH CAROLINA: Beaufort, Godfrey & Tryon 11531 (GH, NY); Berkeley, Wiegand & Manning 2247 (GH, NY); Charleston, Gibbes, summer, 1859 (NY); Darlington, Coker, 1908 (NCU, NY); Georgetown, Godfrey & Tryon 769 (DUKE, GH, NY, PH, US); Horry, Coker, July 27, 1946 (NCU); Orangeburg, Eggleston 5005 (GH, NY, US). TENNESSEE: None.

3. *Eryngium* L. Button Snakeroots, Eryngos.

Glabrous, erect or creeping biennials or perennials. Roots fibrous. Leaves usually tough and simple, often spiny. Heads commonly cymose. Bracts subtending each flower or fruit, variously shaped, sometimes spiny; lower whorl usually much larger. Flowers perfect, regular, sessile. Calyx-segments well developed, persistent. Petals white, greenish, blue, or purple, erect, recurved at tips. Stamens and styles longer than petals. Stylopodium absent; disk present. Ovary and fruit (Fig. 3) covered with hollow, hyaline scales or tubercles. Carpophore absent. Oil-tubes in primary areas. Seed subterete.

Plants erect.
  Veins of leaves parallel; all bracts simple, aristate to acute; flowers greenish or white
  1. *E. yuccifolium*
  Veins of leaves netted; bracts with spines, the upper tricuspidate; flowers bluish.
    Blades of leaves rarely over 5 or 6 cm. long or 3 cm. wide, seldom over three times as long as wide . . . . 2. *E. integrifolium*
    Blades of leaves elongate, obviously over three times as long as wide
    3. *E. aquaticum*
Plants creeping or weakly ascending.
  Bracts at base of heads equal or longer than heads; leaves tapering or palmately lobed at base, sometimes so deeply lobed that they almost appear compound
  4. *E. prostratum*
  Bracts at base of heads shorter than heads; leaves pinnatifid or pinnate
  5. *E. divaricatum*

1. *Eryngium yuccifolium* Michx. (*E. aquaticum* L. [in part]) Eryngo, Button Snakeroot, Rattlesnake Master, Water Eryngo, Corn Snakeroot, Rattlesnake Flag, Rattlesnake Weed.

Perennials with yucca-like leaves; base corm-like; leaves with bristles on margin, bristles usually solitary; basal leaves in a rosette; cauline leaves much smaller; heads globose-ovoid; bracts mostly 1-nerved, longer than ovaries and fruits; flowers white or greenish; fruits and seeds slightly dorsally flattened (Fig. 3) or terete.—Native, sometimes planted in yards. Flowers from spring to fall.

A variety with leaves armed with more than one bristle to a place ranges farther south. Some plants from the coastal plain may appear somewhat intermediate between the species and variety. Two examples of these are Rodgers' collection 870C (NCU) from Pender Co., N. C., and Coker's collection of July 13, 1932 (NCU), from Horry Co., S. C.

DISTRIBUTION: Open places—savannas, bogs, pastures, dry banks, and occasionally in deep woods; mts., pied., and coastal plain. Fla. to Tex., north to Conn. and Minn.; in Southeast (Map VII), all states.

SPECIMENS CITED: ALABAMA: Lee, Pollard & Maxon 78 (NY, US); Mobile, Mohr, July, 1870 (US). FLORIDA: Brevard, Rhoads, June 10, 1937 (DUKE, FLA); Broward, Brown & West, April 16, 1928 (NY, US); Collier, Scull, June 21, 1937 (FLA); Dade, Small & Nash 80 (NY); Escambia, Tisdale, Aug. 12, 1932 (FLA); Gadsden, Chapman, no number or date (NY); Hillsborough, Garber, May, 1874 (PH); Jackson, Biltmore Herbarium 414c (NY); Levy, Garber, June, 1876 (PH); Palm Beach, Fox, June 5, 1945 (NCS); Wakulla, Small et al. 9576 (NY, US). GEORGIA: Baker, Thorne 5402 (US); Habersham, collector unknown, Sept. 1–3, 1894 (NY); Jasper, collector and date unknown (PH); Jenkins, Duncan 9888 (GA, NCU); Meriwether, Harper 1270 (GH, NY, US); Rabun, Cuthbert, Aug. 5, 1889 (FLA); Richmond, McCarthy, Sept., 1888 (NCS); Stephens, Duncan 10021 (GA); Walker, Ruth 421 (NY), 424 (US); Upson, Cronquist 5505 (US). LOUISIANA: Acadia, Degener 5125 (NY); Calcasieu, Correll 9644 (DUKE); Rapides, Ball 632 (US); St. Tammany, Arsene 11667 (US); Tangipahoa, Correll 9311 (DUKE, GH). MISSISSIPPI: Harrison, Tracy 6467 (NCU); Jackson, Pollard 1043 (US); Leake, McDougall 1394 (US). NORTH CAROLINA: Alamance, Ashe, Oct., 1895 (NCU); Brunswick, Rodgers 890C (NCU); Buncombe, Biltmore Herb. 414b (NY); Burke, Rodgers 727C (GA, NCU); Caldwell, Randolph 1121 (GH); Catawba, Small & Heller, June 25–26, 1891 (PH, US); Clay, Rodgers 616C (NCU); Columbus, Rodgers 887C (NCU); Durham, Blomquist 7421 (DUKE); Forsyth, Schallert, Sept. 1, 1932 (NY); Granville, Rodgers 405C (NCU); Harnett, Radford & Stewart 649 (NCU); Haywood, Haliburton 74 (DUKE); Henderson, Rodgers 644C (NCU); Hyde, Correll 1749 (DUKE); Jackson, Thaxter, June–July, 1887 (GH, US); Macon, Rodgers 607C (NCU); Montgomery, Oosting 1880 (DUKE); New Hanover, reported by Curtis & Wood & McCarthy; Orange, Rodgers 392AC (NCU); Pender, Rodgers 870C (GA, NCU, NY); Person, Rodgers 398C (NCU); Polk, Peattie 1091 (NCU); Rowan, Heller 60 (NY, PH); Surry, Rodgers 787C (NCU); Swain, Hunnewell 10451 (GH); Wake, Rodgers 470C (NCU); Warren, Rodgers 414C (NCU). SOUTH CAROLINA: Berkeley, Godfrey & Tryon 855 (DUKE, GH, NY, US); Charleston, Hunt (CLEMS); Darlington, Smith 1473 (NCU); Florence, Talbert & Armstrong, no number or date (CLEMS); Georgetown, Godfrey & Tryon, July 26, 1939 (GH, NY, US); Greenville, Thomason, Aug. 13, 1935 (FUR); Horry, Coker, July 13, 1932 (NCU); Oconee, House 2898 (NY, US); Pickens, Rodgers 233 (DUKE); Sumter, Stone 362 (PH). TENNESSEE: Bledsoe, E. B. H. 7708 (TENN); Bradley, Wherry & Pennell 13994 (PH); Chester, Bain 113 (NY); Coffee, Ford & Russell 2308 (TENN); Cumberland, Coffman 247 (US); Hamilton, Lippincott, Oct. 19, 1895 (PH); Hickman, Sharp & Clebsch 446 (TENN); Knox, Ruth 2842 (NCU); Lewis, Shanks, Clebsch, & Sharp 5763 (TENN); Rhea, Shanks, Sharp, & Clebsch 4369 (TENN); Roane, collector unknown, 1920 (TENN); Van Buren, Shanks, Sharp, & Clebsch 4525 (TENN); White, Sharp, Shanks, & Clebsch 5452 (TENN).

2. *Eryngium integrifolium* Walt. (*E. virgatum* Lam.) Virgate Button Snakeroot, Sea Holly.

Plants slender, up to 9 dm. tall; basal leaves with petioles longer than the elliptic or oblong blades; lower cauline leaves similar, but with short petioles; upper cauline leaves with elliptic, lanceolate, ovate, or oblong blades, longer than petioles; leaf margins entire to coarsely stiff-toothed, sometimes cut; heads globose or ovoid; bracts subtending head linear, equaling or up to twice as long as head, commonly with 2 (often 4–5) spines near base; flowers blue.—Native. Flowers in summer and fall.

DISTRIBUTION: Grass bogs, cane brakes, and savannas; most abundant on coastal plain. Fla. to Tex., north to N. C. and Okla.; in Southeast (Map VII), every state.

SPECIMENS CITED: ALABAMA: Butler, Smith, Aug. 21, 1884 (GH, US); Choctaw, Watson, 1857 (GH); Escambia, Blanton 129 (GH); Lee, Earle & Baker, Sept. 25, 1897 (PH); Mobile, Harvey 18 (US); Tuscaloosa, Vasey 480 (US). FLORIDA: Alachua, Murrill 108 (US); Baker, Curtiss 6008 (FLA, GH, NCU, NY, US); Bay, Billington 9 (US); Calhoun, Hood 2746 (FLA); Clay, O'Neill, Sept. 30, 1929 (US); Escambia, Tisdale, Sept. 14, 1946 (FLA); Franklin, Biltmore Herb. 2357a (GH, NY); Gadsden, Nash 2573 (FLA, GH, NCU, NY, PH, US); Holmes, Curtiss, Aug. 26, 1884 (GH); Jackson, Knight, Oct. 21, 1941 (FLA); Liberty, Curtiss, Aug. 27, —— (NY); Okaloosa, Hood 3123 (FLA); Wakulla, Nash 2539 (GH, NY, PH, US); Walton, Curtiss 1000 (NY, PH, US); Washington, Senner, Aug. 31, 1942 (FLA). GEORGIA: Baldwin, Boykin, no number or date (PH); Bartow, Duncan 8687 (FLA); Clayton, Duncan 9559 (GA); Coffee, Harper 709 (NY); Colquitt, Harper 1665 (GH), 1664 (NY); Columbia, Chapman, 1832 (NY); Coweta, Wiegand & Manning 2262 (GH); Jasper, Porter, no number or date (GH); Jefferson, Hopkins, Oct. 18, 1901 (NY); Jenkins, Cleveland, no number or date (FLA); Liberty, LeConte, no number or date (NY); Long, Duncan 7130 (GA, NCU); Lowndes, Harper 1612 (GH, NY, US); Meriwether, Harper 1252 (GH, NY, US); Polk, collector unknown, Sept., 1891 (US); Sumter, Harper 422 (GH); Thomas, Harper 1181 (NY, US); Union, Wherry & Pennell 14049 (PH); Worth, Pollard & Maxon 547 (NY). LOUISIANA: Calcasieu, Mackenzie 518 (NY); Feliciana (East of West ?), Carpenter (PH); Natchitoches, Palmer 8808 (PH); Orleans, collector and date unknown (GH); Rapides, Hale, no number or date (NY, PH); St. Tammany, Pennell 4177 (NY); Webster, Correll 10312 (DUKE, GH, NCS, NY, PH). MISSISSIPPI: Forest, Oosting 1968 (DUKE); Harrison, Tracy 4479 (GH); Jackson, Seymour & Earle 91822103 (DUKE, GH, NCU); Pearl River, Kearney, Oct. 12, 1896 (NY); Simpson, Tracy 8437 (GH, NY, US). NORTH CAROLINA: Bladen, Blomquist, Aug. 17, 1932 (DUKE); Brunswick, Rodgers 889C (GA, NCU); Buncombe, Biltmore Herb. 2357b (GH, NCU, NY, US); Burke, Blomquist, July 30, 1933 (DUKE); Carteret, Rodgers 853C (GA, NCS, NCU, NY); Cherokee, Ashe, Sept., 1893 (NCU); Columbus, Rodgers 881C (GA, NCS, NCU, NY); Craven, Rodgers 853AC (DUKE) (NCU); Haywood, reported by Harper; Henderson, Rodgers 643C (GA, NCS,

NCU, NY, US); Iredell, Hyams, July, 1878 (NY, US); Johnston, Blomquist 10538 (DUKE); Nash, Godfrey & Kerr, Oct. 8, 1938 (DUKE, NCS); New Hanover, Radford 659 (NCU); Onslow, Rodgers 873C (DUKE, NCS, NCU); Pamlico, Godfrey & White, Oct. 13, 1938 (DUKE, GH, NCS); Pender, Rodgers 869C (NCU); Richmond, Williamson, Aug. 1, 1896 (PH); Swain, Beardslee & Kofoid, Aug. 28, 1891 (GH, NY, US); Wake, Hyams, no number or date (NCU). SOUTH CAROLINA: Anderson, Davis 7827 (US); Berkeley, Coker, Aug. 29, 1902 (NCU); Charleston (?), Porcher, no number or date (NY); Darlington, Norton, June, 1921 (NCU); Dorchester, Hunt 1183a (CLEMS); Georgetown, Totten, Sept. 7, 1940 (NCU); Horry, Schallert, Sept. 1, 1940 (GH). TENNESSEE: McNairy, Svenson, Aug. 28, 1930 (GH, PH).

3. *Eryngium aquaticum* L. (E. *virginianum* Lam.) Marsh Button Snakeroot, Virginian Eringo.

Plants perennial, up to 12 dm. tall; leaves linear to lanceolate or oblanceolate, margins entire, crenate, or serrate, apex acute or obtuse; basal leaves with petioles longer than blades; cauline leaves with blades longer than petioles; upper leaves sessile; heads subglobose; bracts of lower series about equal to or up to twice length of heads, 1-nerved, usually with 2–3 spines; other bracts tricuspidate, the center spine longest; flowers blue.—Native. Flowers in summer and fall.

A variety having bracts with three equal spines ranges farther south.

DISTRIBUTION: Swamps and margins of streams; coastal plain. Ala. and Ga. to N. J.; in Southeast (Map VII), Ala., Ga., S. C., and N. C. (Small gives the range as far west as Tex.).

SPECIMENS CITED: ALABAMA: Mobile, Mohr, Sept. 10, 1882 (US). FLORIDA: None. GEORGIA: Chatham, Hopkins 30 (NY); Effingham, Harper 1839 (GA, NY, US); Liberty, LeConte, no number or date (NY); McIntosh, Small, June 26, 1895 (NY). LOUISIANA: None. MISSISSIPPI: Reported by Lowe. NORTH CAROLINA: Beaufort, Radford & Stewart 773 (NCU); Brunswick, Godfrey & Wells 4888 (GH, NCS); Carteret, Rodgers 856C (GA, NCS, NCU); Chowan, Bartley & Pontius 504 (NY); Craven, Rodgers 851C (DUKE, GA, NCS, NCU, NY, US); Currituck, Barber, Aug. 28, 1948 (NCS); Hyde, Godfrey & White 6855 (DUKE, GH, NCS); New Hanover, Williamson, Aug., 1900 (PH); Onslow, Godfrey 6399 (GH, NCU, US); Pasquotank, Kearney 2009 (US); Tyrrell, Radford 5078 (NCU). SOUTH CAROLINA: Aiken, Ravenel, 1870 (NY); Beaufort, Mellichamp, 1875 (GH), 1887 (NY, US); Berkeley, Ravenel, no number or date (GH, NY); Charleston, Godfrey & Tryon 1143 (GH, NY, US); Georgetown, Godfrey 8131 (DUKE); Jasper, Wiegand & Manning 2258 (GH); Marion, Wiegand & Manning 2257 (GH). TENNESSEE: None.

4. *Eryngium prostratum* Nutt. Prostrate Eryngo.

Plants creeping perennials, sometimes rooting at the nodes; basal leaves ovate, lanceolate, or oblong, margins entire or toothed; cauline leaves clustered at

nodes, entire, with few teeth, or deeply 3-parted (appearing almost compound), short-petiolate or sessile; heads 4–9 mm. long, longer than wide; bracts subtending bottom flowers of head 5–10, equal or longer than heads; other bracts shorter than fruits; flowers blue.—Native.

In 1945, Fernald discovered *E. prostratum* in Southampton County, Virginia. He described it as a new variety (*E. prostratum* var. *disjunctum* Fern.), indicating that "its fruits are usually more elongate, tending to obconic, usually narrower than the typical form and with stipitate papillae." From the limited material available it is difficult to see a difference.

He noted the considerable distance between this new location and the Colleton County (South Carolina) station, which was the most northern location he knew. Actually, Fosberg had collected it at Motlow Creek in Spartanburg County, South Carolina, this station being further north and a little nearer Fernald's station. Fosberg's collection is particularly interesting, because it is from the very edge of the mountains while all other collections have been from the coastal plain.

No collections are known from North Carolina, but it may occur here.* It is often confused with *E. baldwini*, which is further south.

DISTRIBUTION: Low, wet places; chiefly coastal plain. Fla. to Tex., north to S. C., Va. (described as a variety), Ky., Mo., and Okla.; in Southeast (Map VII), all states except N. C.

SPECIMENS CITED: ALABAMA: Mobile, Mohr, 1897 (GH). FLORIDA: Alachua, Murrill, May 24, 1941 (FLA); Columbia, Rolfs, June 18, 1894 (FLA); Gadsden, Foster 30 (FLA); Gilchrist, Martin, DeVall, & Arnold, May 19, 1940 (FLA); Lafayette, West & Arnold, May 20, 1941 (FLA); Leon, Wiegand & Manning 2264 (GH); Levy, Murrill, April 24, 1941 (FLA); Suwanee, Wiegand & Manning 2265 (GH); Taylor, Wilmot & Murrill, May 13, 1941 (FLA). GEORGIA: Camden, Wood & Clement 7127 (GH); Decatur, Thorne 3953 (US); Jefferson, Pyron & McVaugh 1714 (US); Jenkens, Harper 777 (US); Sumter, Harper 1047 (GH, US); Thomas, Curtiss 6814 (GH, US); Ware, Williamson, no number or date (PH). LOUISIANA: East Baton Rouge, Ball 382 (US); Calcasieu, Allison, 1904 (GH, US); Feliciana (East or West ?), Carpenter, 1840 (US); Natchitoches, Palmer, May 3, 1915 (US); Rapides, Ball 472 (GH, US); St. Tammany, Arsene 12398 (US). MISSISSIPPI: Adams, Rhoades, July, 1931 (GH); Lauderdale, Tracy, June 6, 1891 (US); Scott, Anderson 4519 (DUKE); Simpson, Tracy 8631 (GH, US). NORTH CAROLINA: None. SOUTH CAROLINA: Colleton, Wiegand & Manning 2263 (GH); Spartanburg, Fosberg 18966 (NCU). TENNESSEE: Benton, Sharp, Clebsch, & Shanks 5945 (TENN); Carroll, Svenson 443 (GH); Chester, Bain, Aug., 1892 (US); Haywood, Gattinger, Aug., 1884 (GH); McNairy, Svenson 4334 (GH); Tipton, Sharp & Clebsch 6431 (TENN).

* Mr. R. K. Godfrey writes that he has collected a prostrate *Eryngium* on the Tar River, North Carolina. I have not yet seen his specimen but it may be this species.

5. *Eryngium divaricatum* H. & A.

Plants weak, slender-stemmed perennials; basal leaves pinnate or pinnately lobed, segments lanceolate, entire, and acute; cauline leaves similar, but segments closer together; flowers greenish.—Introduced.

This plant was collected on ballast by Gerald McCarthy at Wilmington in 1892. Additional collections either at Wilmington or elsewhere in the state are not known, and recent collecting in the same area failed to disclose it. It seems likely that it did not become permanently established. It was introduced at Pensacola, Florida, on ballast and collected by A. H. Curtiss in 1897.

DISTRIBUTION: Low waste-places. Introduced at Wilmington, N. C., and Pensacola, Fla. (Map VII).

SPECIMENS CITED: FLORIDA: Escambia, Curtiss, July 2, 1897 (NY). NORTH CAROLINA: New Hanover, McCarthy, June, 1892 (NY).

4. SANICULA L. Black Snakeroots, Sanicles.

Glabrous or pubescent, branching biennials or perennials. Roots fibrous, sometimes fleshy. Leaves palmately or pinnately compound or decompound, commonly palmately 3- or 5-foliate, basal blades often deeply cut. Umbels simple, cymosely displayed. Flowers in umbel usually 3 sessile or pedicellate perfect flowers and 0 to many staminate ones; some umbels entirely staminate. Flowers regular. Calyx-segments conspicuous, often sharp-pointed. Petals white, greenish, yellow, or purple, erect, recurved at tips. Stamens usually longer than petals. Styles shorter or longer than petals. Stylopodium absent; disk present. Ovary scaly and spiny. Fruit bristly, somewhat laterally flattened. Carpophore absent. Oil-tubes large and solitary in primary areas or numerous, small, and indefinitely arranged. Seed nearly terete; face plane to sulcate.

Styles shorter than calyx-segments of flower or fruit.
  Ovary or fruit on a short stalk; stamens long, exserted; mature fruit 5 mm. or less long, not distinctly beaked.......................................1. *S. canadensis*
  Ovary or fruit sessile or subsessile; stamens short, included; mature fruit 6 mm. long or longer, calyx-segments forming a distinct beak.......................2. *S. trifoliata*
Styles longer than calyx-segments of flower or fruit.
  Styles less than twice the length of calyx-segments and not extending beyond tips of bristles in flowers and fruits; roots tuberous, not black; petals shorter than or almost equal calyx-segments; staminate flowers few, never in separate umbels, their sepals tending to spread apart and appear star-shaped when fruits mature, each of their inner surfaces with a conspicuous mid-nerve..........................3. *S. smallii*
Styles much longer than calyx-segments and bristles in flowers and fruits; roots black, not tuberous; petals about equal or longer than calyx-segments; staminate flowers tending to be numerous, sometimes in separate umbels.
  Ovary or fruit sessile or subsessile; calyx-segments deeply cleft, awl-shaped; petals greenish-white, about equal or longer than calyx-segments; old staminate flowers on pedicels 3–4 mm. long, usually equal or exceeding length of mature fruit; plants tending to be solitary and to have 0–3 basal leaves..............4. *S. marilandica*

Ovary or fruit on a short stalk; calyx-segments cleft about ½ distance to top of ovary, triangular-ovate, acute or obtuse, membranous; petals yellow, much longer than calyx-segments; old staminate flowers on pedicels 1.5–2 mm. long and shorter than mature fruits; plants tending to be clustered and to have several basal leaves.
5. *S. gregaria*

1. *Sanicula canadensis* L. (*S. floridana* Bickn.; *S. canadensis* var. *floridana* [Bickn.] H. Wolff) Canada Sanicle, Short-styled Snakeroot.

Plants biennial, up to 13 dm. tall; roots fibrous to slightly fleshy; leaves trifoliate with basal blades deeply cut; basal leaves 0–3; cyme usually compounded 3–4 times; umbels with 3–8 flowers, usually 3 perfect and 2 staminate; petals white or greenish, shorter than calyx-segments; bristles of fruit (when young) bent over into secondary areas so that they appear in 8 rows; fruit (Fig. 4) 2–5 mm. long, almost orbicular; seed sulcate under oil-tubes.—Native. Flowers from spring to fall.

Sanicula canadensis var. *floridana* (Bickn.) Wolff (*S. floridana* Bickn.) is a variant from the typical species, but no attempt has been made to distinguish them here. There is a considerable amount of intergradation. This variant is rarely seen on the coastal plain of North Carolina. It is a smaller plant with thicker leaf blades and stiffer bristles on the teeth.

DISTRIBUTION: Common in woods and along streams; mts., pied., and coastal plain. Fla. to Tex., north to Vt., Ont. (Macoun 53985; NY), and Wyo. (Williams 190; NY); in Southeast (Map VI), all states.

SPECIMENS CITED: ALABAMA: Clay, Mohr, July 30, 1896 (US); Hale, Harper 3063 (NY, US); Jackson, Harbison 4471 (NCU); Lee, Pollard & Maxon 38 (US); Madison, Pollard & Maxon 379 (NY, US); Mobile, Mohr, June, 1896 (US). FLORIDA: Alachua, O'Neill 642 (US); Clay, Arnold & West, July 15, 1947 (FLA); Columbia, Rose 2244 (FLA, NCU, NY, PH, US); Duval, Fredholm 5285 (US); Hernando, Davis, July 18, 1934 (FLA); Jackson, Arnold & West, May 7, 1948 (FLA); Lake, Marsh 988 (NY, US); Leon, Kurz, Aug. 31, 1942 (FLA); Levy, Murrill, April 23, 1939 (FLA); Liberty, Beck, July 23, 1947 (FLA); Marion, Blake, April 2, 1950 (FLA); Volusia, Hood, June 27, 1910 (FLA); Walton, Hume, June 7, 1938 (FLA). GEORGIA: Chatham, Eyles 4638 (DUKE); Clarke, Pyron, July 5, 1929 (DUKE); Columbia, Duncan 9741 (GA, NCU); DeKalb, Small, July 25, 1893 (NY, US); Early, Harper 1221½ (NY); Floyd (?), Chapman 2197 (US); Fulton, Duncan 9595 (GA); Houston, Ainsworth, June 25, 1944 (PH); Jefferson, Hopkins 29 (NY); Lincoln, Duncan 9821 (GA, NCU); Oglethorpe, Cronquist 4581 (GH); Rabun, Radford, June 20, 1946 (NCU); Richmond, Cuthbert, Aug. 11, 1907 (NY); Sumter, Harper 1042 (NY). LOUISIANA: Calcasieu, Allison 144 (NY, US); Rapides, Correll 9859 (DUKE, PH); St. Tammany, Arsene 11865 (US). MISSISSIPPI: Harrison, Pollard 1050 (US); Jackson, collector unknown, June 1896 (NY); Jasper, Tracy 3320 (NY). NORTH CAROLINA: So common throughout the state that citations of county records (73) are omitted to save space. SOUTH

CAROLINA: Aiken, Radford 546 (NCU); Anderson, Gibbes, 1886 (NY); Berkeley, Godfrey & Tryon 142 (DUKE, NY, PH, TENN, US); Charleston, Hunt & Martin 156 (CLEMS); Clarendon, Godfrey & Tryon 995 (DUKE); Darlington, Smith 1481 (NCU); Georgetown, Godfrey & Tryon 109 (NY, US); Greenville, Thakston, July, 1920 (FUR); Horry, Powell, June 22, 1937 (FUR); Lexington, McGregor 253 (US); Marlboro, Radford & Stewart 413 (NCU); Oconee, collector unknown, July 2, 1897 (NY); Orangeburg, Godfrey & Tryon 796 (NY, US); Pickens, House 3497 (NY). TENNESSEE: Bradley, Benner 5811 (PH); Chatham, Svenson 10392 (DUKE, PH, US); Cocke, Kearney 709 (US); Davidson, Bicknell 6702 (NY); Grainger, Morrison & Brown 16 (TENN); Knox, Kearney, July 9, 1894 (NY, US); Maury, Svenson 9048 (DUKE); Rutherford, Quarterman 1669 (DUKE); Unicoi, Price 864 (DUKE); Union, Kalter, June 16, 1936 (TENN); Van Buren, Ford & Russell 1993 (TENN); Warren, Svenson 9384 (DUKE).

2. *Sanicula trifoliata* Bickn. Large-fruited Snakeroot.

Plants biennial, up to 9 dm. tall; roots fibrous; leaves trifoliate, the basal leaflets often deeply cut; calyx-segments subulate, curving inward slightly; petals white; fruits 6–8 mm. long; oil-tubes small and numerous, sometimes with 2 large lateral ones.—Native. Flowers from spring to fall.

DISTRIBUTION: Woods. N. C. and Tenn., north to Vt., Ind., and Ont.; in Southeast (Map VI), N. C. and Tenn.

SPECIMENS CITED: NORTH CAROLINA: Clay, Wilbur 1265 (DUKE); Mitchell, Cannon 101 (NY). TENNESSEE: Davidson, Svenson 88 (NY, PH); Sevier, Cain, June 13, 1937 (TENN).

3. *Sanicula smallii* Bickn.

Plants perennial, up to 6 dm. tall; roots fleshy; stems seldom branching except at top; leaves thickish, trifoliate with basal blades deeply cut; cyme usually compounded 1–3 times; flowers usually 3 perfect and 2–8 staminate to an umbel; calyx-segments subulate; petals greenish-white, shorter than calyx-segments; fruits 3–5 mm. long, about orbicular; oil-tubes 5, large; seed sulcate under oil-tubes.—Native. Flowers from spring to fall.

DISTRIBUTION: Deciduous woods; mts., pied., and coastal plain. Fla. to Tex., north to Va. and Mo.; in Southeast (Map VI), all states.

SPECIMENS CITED: ALABAMA: Clarke, Mohr, April 24, 1888 (US); Lee, Earle, May 1, 1896 (NY); Madison, Pollard & Maxon 377 (US); Tuscaloosa, Smith, 1877 (US); Walker, Earle, June 19, 1899 (NY). FLORIDA: Gadsden, Kincaid & West, April 18, 1930 (FLA); Leon, Nash 2362 (NCU); Liberty, O'Neill 566 (US). GEORGIA: Burke, Leeds & Harper 2760 (PH); Clarke, Harper 143 (NY, US); Columbia, Duncan 9510 (GA, NCU); De Kalb, Small, July 25, 1892 (US); Floyd, Chapman, no number or date (US); Gordon, Leeds 2124 (PH); Richmond, Cuth-

bert, May 15, 1904 (FLA). LOUISIANA: Natchitoches, Palmer 7513 (NY, US). MISSISSIPPI: County unknown, Clute 94 (NY). NORTH CAROLINA: Alamance, Totten et al., May 22, 1937 (NCU); Anson, Rodgers 777C (GA, NCU); Burke, Rodgers 729C (DUKE, NCU); Cabarrus, Rodgers 768C (NCU); Caldwell, Small & Heller 338 (US); Durham, Blomquist 4409 (DUKE); Forsyth, Rodgers 781C (NCS, NCU); Jackson, Rodgers 602C (NCU); Johnston, Fox & Godfrey 1661 (NCS); McDowell, Rodgers 717C (NCU); Orange, Rodgers 250C (NCU); Polk, Churchill, May 29, 1899 (TENN); Randolph, Rodgers 439C (NCU, US); Rutherford, Rodgers 733 (NCU); Stanly, Small & Heller, Aug. 8, 1891 (NY); Wake, Wells, June 30, 1942 (NCS); Warren, Rodgers 412C (NCU, NY, US); Wilkes, Rodgers 793C (DUKE, NCU). SOUTH CAROLINA: Abbeville, Branch, 1855 (NY); Greenville, Batson, May 31, 1934 (FUR); Richland, Philson, May 18, 1936 (DUKE). TENNESSEE: Cocke, Kearney 710 (NY, US); Hamilton, Bicknell, June 21, 1894 (NY); Jackson (?), Bain 302 (NY); Knox, Bain, April 30, 1933 (TENN); Loudon, Cain & Sharp 4505 (TENN); Montgomery, Clebsch, April 27, 1946 (TENN).

4. *Sanicula marilandica* L. (*S. marilandica* var. *petiolulata* Fern.) Black Snakeroot.

Plants perennial, up to 13 dm. tall; roots fibrous, black; leaves 3- or 5-foliate with basal blades deeply cut; basal leaves 0–3; cyme usually compounded 2–3 times; umbel with few to 40 flowers, spherical, usually 3 perfect flowers and numerous staminate ones, some umbels completely staminate; calyx-segments subulate; petals greenish-white, equal or longer than calyx-segments; fruits 4–6 mm. long, nearly orbicular; oil-tubes 5, large; seed sulcate under oil-tubes.—Native. Flowers from spring to fall.

DISTRIBUTION: Woods; mts., pied., and coastal plain. Fla. to N. M., north to Newf. and B. C.; in Southeast (Map VI), all states except Miss. (reported) and La. (probably present).

SPECIMENS CITED: ALABAMA: Lee, Earle 197 (US). FLORIDA: Alachua, Arnold & West, April 4, 1939 (FLA); Gadsden, Kincaid & West, April 18, 1930 (FLA); Madison, Murrill, 1940 (FLA). GEORGIA: Cobb, Harper 224 (US); Early, Harper 1908 (US); Grady, Cronquist 5459 (FLA, GH); Rabun, Small, Aug. 4, 1893 (NY); Richmond, McCarthy, June, 1888 (US). LOUISIANA: None. MISSISSIPPI: Reported by Lowe. NORTH CAROLINA: Ashe, Rodgers 809C (NCU); Buncombe, Biltmore Herb. 882a (NCU); Burke, Ashe, no number or date (NCU); Clay, Rodgers 613C (NCU); Craven, reported by Croom; Dare, Fox & Godfrey 2318 (NCS); Durham, Blomquist 4414 (DUKE); Forsyth, Schallert 8572 (DUKE); Gaston, Rodgers 743C (NCU); Johnston, collector and date unknown (NY); Mecklenburg, Rodgers 745C (NCU); Mitchell, reported by Gray; New Hanover, reported by Wood & McCarthy; Orange, Rodgers 249C (NCU); Pender, Godfrey 6583 (NCU); Polk, Peattie 1191 (NCU); Stanly, reported by Small & Heller; Wake, Godfrey 3943 (DUKE); Watauga, reported by Small & Heller. SOUTH CAROLINA:

Aiken, Ravenel, Sept., 1869 (US); Charleston, Moldenke 1194 (DUKE); Darlington, Rodgers, April 3, 1910 (NCU); Florence, Bartram 2304 (PH); Pickens, Rodgers 338 (DUKE). TENNESSEE: Cocke, Kearney 708 (NCU, US).

5. *Sanicula gregaria* Bickn. Clustered Sanicle, Clustered Snakeroot.

Plants perennial, up to 9 dm. tall; roots fibrous, black; leaves thin, bright-green, trifoliate with basal blades deeply cut; basal leaves usually several; cyme compounded up to 4 times; umbels spherical with few to 30 flowers, usually 3 perfect and several staminate, some umbels entirely staminate; calyx-segments thin, triangular to ovate, acute or obtuse; petals yellow, longer than calyx-segments; fruit orbicular to obovoid, 3–5 mm. long, with widely spaced bristles; oil-tubes 5, large; seed not sulcate under oil-tubes.—Native. Flowers from spring to fall.

DISTRIBUTION: Low, damp woods; mts., pied., and coastal plain. Fla. to La., north to Que. and S. D.; in Southeast (Map VI), all states except Miss. (probably present).

SPECIMENS CITED: ALABAMA: Hale, Harper 3063 (PH); Marshall, Harper 3350 (PH, US); Montgomery, Harper 84 (US). FLORIDA: Calhoun, Oosting 106 (DUKE); Gadsden, Arnold & West, March 14, 1937 (DUKE); Jackson, Knight, April 5, 1944 (FLA). GEORGIA: Early, Harper 1221 (US); Rabun, Duncan 9559 (GA, NCU); Randolph, Harper 1887 (US); Richmond, Cuthbert, no number or date (FLA); Whitfield, Harper 256 (US). LOUISIANA: Feliciana (East or West ?), Carpenter, April, 1840 (US). MISSISSIPPI: None. NORTH CAROLINA: Buncombe, Biltmore Herbarium 4816 (US); Cabarrus, Rodgers 769C (DUKE, GA, NCS, NCU); Cherokee, Jennison 589 (TENN); Durham, Anderson 6282 (FLA, PH); Guilford, Rodgers 371C (DUKE, NCS, NCU); Halifax, Williamson, April 19, 1908 (PH); Haywood, Blomquist 4413 (DUKE); Henderson, reported by Memminger; Jackson, Radford, June 26, 1946 (NCU); Macon, Ashe, May 24, 1893 (NCU); Mitchell, Cannon, July 16, 1902 (US); Orange, Totten, May 13, 1936 (NCU); Polk, Peattie 2206 (NCU); Watauga, Ashe, May 23, 1893 (NCU). SOUTH CAROLINA: Charleston, Hunt 2246 (CLEMS); Oconee, House 2126 (US); Richland, Philson, April 23, 1936 (DUKE). TENNESSEE: Knox, Lamson-Scribner, May 10, 1890 (US); Lewis, King 70 (DUKE); Sevier, Drew, May 16, 1937 (TENN); Shelby, Sharp, Felix, & Adams 12002 (TENN); Sullivan, Jennison, Sharp, & Underwood 818 (TENN).

5. DAUCUS L. Carrots.

Pubescent (rarely glabrous), erect, simple or branching annuals and biennials. Taproots. Leaves pinnately decompound. Umbels compound, opposite leaves. Bracts simple to pinnately decompound; bractlets simple, ternate, or pinnate. Flowers tending to be irregular. Calyx-teeth absent or distinct. Petals white (less commonly yellowish, pink, or purple), spreading, recurved at tip. Stylopodium conic. Ovary bristly. Fruit almost terete or slightly laterally flattened; primary

ribs bristly; secondary ribs toothed, their tips usually barbed. Carpophore usually entire. Oil-tubes solitary under secondary ribs. Seed dorsally flattened, face slightly concave.

Bracts mostly pinnately decompound, spiny-hispid; bractlets simple, linear, and mostly entire; outside rays usually less than 30 mm. long; central flower of central umbelet like the others; teeth with caps of barbs at their apexes . . . . 1. *D. pusillus*
Bracts pinnately divided, 3-parted, or rarely simple; bractlets simple to pinnate; outside rays mostly over 35 mm. long; central flower of central umbelet often rose or purple colored; teeth with one or two inconspicuous barbs at apex or barbs absent 2. *D. carota*

1. *Daucus pusillus* Michx. Dwarf Carrot, American Carrot.

Annual plants up to 10 dm. tall, sparingly branched; flowers white; stamens about length of petals; styles shorter than petals; fruit ovoid to ellipsoid; teeth of secondary ribs usually about 8 to a row.—Native weed. Flowers from spring to fall.

DISTRIBUTION: Waste-places; chiefly coastal plain. Fla. to N. C., west to Tex., Kans., Mex., Calif., and up west coast to B. C., in Southeast (Map V), all states; in N. C., southeast corner of state.

SPECIMENS CITED: ALABAMA: Baldwin, Schallert 527 (DUKE); Mobile, Mohr, June, 1883 (US); Wilcox, Nuttall, May, 1893 (NY). FLORIDA: Alachua, Weber, June 7, 1928 (FLA); Citrus, Small 10389 (US); Columbia, Rolfs 143 (FLA); Duval, Curtiss 6164 (NCU); Escambia, Blanton 6571 (US); Gadsden, Foster, June 2, 1936 (FLA); Liberty, Chapman 375 (US); Union, West & Arnold, May 22, 1942 (FLA); Wakulla, Moldenke 1121 (DUKE, NY); Walton, Small, summer, 1885 (NY). GEORGIA: Jenkins, Harper 758 (GH, NY, US); Decatur, Small, June 4, 1895 (NY); De Kalb, Eggert, May 23, 1897 (NY); Thomas, O. E.—, June 11, 1945 (FLA). LOUISIANA: Orleans, Drummond, 1832 (GH); Rapides, Ball 392 (GH, NY, US); St. Landry, Carpenter, no number or date (PH); St. Martin, Langlois, May 9, 1893 (US); St. Tammany, Arsene 11838 (US). MISSISSIPPI: Jasper, Tracy 3315 (NY); Madison, McDougall 1353 (US). NORTH CAROLINA: Brunswick, Rodgers 284AC (NCU, NY, US); Craven, Rodgers 338AC (NCU, NY, US); New Hanover, Rodgers 301C (DUKE, GA, NCS, NCU, NY); Pender, A. C. W., May 21, 1925 (NCS). SOUTH CAROLINA: Aiken, Ravenel, 1870 (NY); Beaufort, Cuthbert, May, 1883 (FLA); Berkeley, Ravenel, May,— (GH); Charleston, Hunt 1555 (CLEMS); Clarendon, Stone 550 (PH); Florence, Bartram, May 17, 1912 (PH); Lexington, McGregor 46 (US); Oconee, collector unknown, June 24, 1897 (NY); Pickens, collector unknown, July 7, 1897 (NY); Richland, Taylor (US); Sumter, Bartram, May 17, 1912 (PH). TENNESSEE: Davidson, Svenson 9076 (GH).

2. *Daucus carota* L. Wild Carrot, Bird's nest, Crow's-nest, Queen Anne's Lace, Lace-flower, Rantipole, Devil's Plague.

Plants annual or biennial, up to 15 dm. tall; flowers white, pink, yellowish, or purple; outer flowers often distinctly radiant; central flower or central umbe-

let at times partially or entirely purple; stamens mostly longer than petals; styles shorter than petals; fruit (Fig. 5) ellipsoid or oblong; teeth of secondary ribs usually over 10 to a row.—Introduced weed. Flowers from spring to fall.

This weed has spread rapidly since its introduction. It is an interesting fact that in the Southeast it does not occur as abundantly within the range of *D. pusillus* as it does farther north. It is not known whether the climate is not suitable or whether it has not yet reached its maximum spread.

DISTRIBUTION: Almost anywhere, but most abundant in waste places. Throughout N. A.; in Southeast (Map V).

SPECIMENS CITED: ALABAMA: Jackson, Porter, June 13, 1938 (GH); Mobile, Zimmer, June, 1884 (US). FLORIDA: Jefferson, Burger, Sept. 19, 1927 (FLA); Volusia, Butts, Aug., 1943 (GH). LOUISIANA: None. MISSISSIPPI: Reported by Brown. NORTH CAROLINA: So common throughout the state that citations of county records (80) are omitted to save space. Specimens have not been seen from the following counties (all in the coastal plain, especially in southeastern corner): Bladen, Brunswick, Carteret, Columbus, Cumberland, Duplin, Greene, Hoke, Hyde, Johnston, Jones, Lenoir, New Hanover, Onslow, Pender, Perquimans, Pitt, Robeson, Sampson, and Wayne. SOUTH CAROLINA: Darlington, Smith 593 (NCU); Greenville, Powell, May 27, 1931 (FUR); Oconee, Rosenkrans & Rice, June 8, 1926 (CLEMS). TENNESSEE: Carter, Brown 90 (DUKE); Knox, Totten (NCU); Obion, Eyles 8399 (GH); Unicoi, Price 737 (DUKE).

6. TORILIS Adans.

Pubescent, erect or spreading annuals. Taproots. Leaves pinnate or pinnately decompound. Umbels open or compact, opposite leaves. Bracts absent or simple; bractlets simple. Flowers irregular. Calyx-teeth distinct or obsolete. Petals white, spreading, recurved at tips. Stylopodium conic. Ovary and fruit laterally flattened, bristly or tuberculate. Carpophore split from $\frac{1}{3}$ to $\frac{1}{2}$ distance from apex. Oil-tubes solitary under secondary ribs, 2 on commissure. Seed slightly dorsally flattened, face concave or sulcate.

Inflorescence a distinct umbel, regular. . . . . .1. *T. japonica*
Inflorescence compact, irregular. . . . . .2. *T. nodosa*

1. *Torilis japonica* (Houtt.) D. C. (*T. anthriscus* C. C. Gmel.) Erect Hedge Parsley, Rough Chervil, Hemlock Chervil, Rough Cicely.

Plants erect, appressed-hispid, up to 12 dm. tall; leaves decompound; leaflets toothed or deeply lobed; peduncles longer than the leaves they oppose, rays 3–10, up to 3.5 cm. long; bracts absent or 1–several, simple; bractlets longer than pedicels, subulate; fruit (Fig. 6) ellipsoid, 1.5–4 mm. long, covered with uncinate, glochidiate bristles. Introduced weed. Flowers in spring and summer.

This plant was probably introduced to North Carolina in seeds used for planting on road shoulders. Both known locations are in adjacent counties. A

large stand at Morrow Mt. State Park was along the edge of the recently developed parking area.

DISTRIBUTION: Waste-places. Known from Ala., Calif., D. C., Ill., Ind., Kans. (Horr E90; GH), Ky., Mo., N. C., N. J., N. Y., Ohio, Ore., Penn., Tenn., Tex., and Va.; in Southeast (Map V), Ala., Tenn., and N. C.

SPECIMENS CITED: ALABAMA: Jefferson, Harper 3676 (GH, NY); Marshall, Harper 3587 (NY, US). NORTH CAROLINA: Montgomery, Radford & Rodgers 459C (DUKE, GA, NCS, NCU, NY, US); Stanly, Rodgers 583C (NCU). TENNESSEE: Davidson, Svenson 7080 (GH); Marion, Sharp & Underwood 2553 (TENN); Rutherford, Quarterman, June 21, 1947 (DUKE).

2. *Torilis nodosa* (L.) Gaertn. Knotted Hedge Parsley.

Plants spreading, appressed-hispid, up to 6 dm. tall; leaves decompound, the ultimate divisions mostly linear; peduncles absent or much shorter than the leaves they oppose; rays absent or very short; bracts absent or 1–2, simple; bractlets longer than pedicels, linear; fruit ellipsoid to ovoid, the outside ones usually having one mericarp armed with uncinate, glochidiate bristles and the other warty, the inside fruits warty.—Introduced weed. Flowers in spring and summer.

DISTRIBUTION: Waste-places. Known from Ala., Calif., Ga., La., N. C., Ore., Penn., S. C., and Tex.; in Southeast (Map V), Ala., Ga., La., N. C., and S. C.

SPECIMENS CITED: ALABAMA: Montgomery, Harper 17 (GH, NY, PH, US). GEORGIA: Richmond, Biltmore Herb. 7594a (US). LOUISIANA: Plaquemines, Langlois, 1885 (NY). NORTH CAROLINA: Carteret, Blomquist & Batson 14975 (DUKE, NCS). SOUTH CAROLINA: Beaufort, Churchill 623 (GH).

7. SCANDIX L.

Pubescent, erect, branching annuals. Taproots. Leaves pinnately decompound. Umbels simple or compound, opposite leaves. Bracts absent in compound umbels; bractlets present. Flowers irregular, perfect and staminate. Calyx-teeth obsolete. Petals white, spreading, recurved at tip. Stylopodium low, conic. Ovary elongate, slender-beaked above, ribbed, strigose on body and margin of beak. Carpophore entire or nearly so. Oil-tubes solitary between ribs or absent. Seed slightly dorsally flattened, face deeply sulcate (Fig. 7).

1. *Scandix pecten-veneris* L. Venus' Comb, Lady's Comb, Shepherd's Needle.

Plants up to 5 dm. tall; leaf divisions linear, acute; umbels simple, usually 2 together or compound with 2 rays; bractlets (bracts of simple umbel) with ciliate margins, usually 2-lobed at apexes, but may be entire to pinnate; perfect and staminate flowers in same umbelet or separate; styles short; fruit (Fig. 7) up to

7 cm. long with beak 5–7 times longer than body, beak dorsally flattened.—Introduced weed.

DISTRIBUTION: Waste-places. Known from Ala., N. C., D. C., Penn., N. J., Tex., Calif., Ore., and B. C.

SPECIMENS CITED: ALABAMA: Mobile, Mohr, June, 1885 (US). NORTH CAROLINA: Durham, Blomquist 13453 (DUKE); Iredell, Hyams, June, 1898 (US); Mecklenburg, Phillipps, no number or date (NCS); Wake, Wells, May 10, 1949 (NCS).

8. OSMORHIZA Raf. Sweet Cicelies.

Pubescent to glabrous, branching perennials. Roots clustered, somewhat fleshy. Leaves 2- or 3-ternate or ternate-pinnate; blades broad. Umbels compound, opposite leaves. Bracts few and foliaceous or absent; bractlets several to absent. Flowers regular, perfect and staminate. Calyx-teeth obsolete. Petals white, purplish, or yellow, recurved at tips. Stylopodium conic. Ovary and fruit elongate, laterally flattened, filiform-ribbed. Carpophore split at top. Oil-tubes small or absent. Seed subterete, face deeply sulcate (Fig. 8).

Style and stylopodium together in flower less than 1 mm. long, shorter than petals, in fruit less than 1.5 mm. long 1. *O. claytoni*
Style and stylopodium together in flower 1.5–2.5 mm. long, longer than petals, in fruit 3–4 mm. long 2. *O. longistylis*

1. *Osmorhiza claytoni* (Michx.) Brit. (*O. brevistylis* D. C.) Woolly or Hairy Sweet Cicely, Sweet Jarvil.

Plants up to 10 dm. tall; stem with soft, long pubescence or rarely glabrous; leaf blades thin, ovate or lanceolate, coarsely serrate, some incised; umbels fairly symmetrical in flower, but highly asymmetrical in fruit; rays 2–5; ovary and fruit elongate, strigose on base and ribs; fruits clavate or oblong-clavate, about 15–24 mm. long.—Native. Flowers in spring.

DISTRIBUTION: Deep woods; pied. and mts. in this area. N. C. and Ala., north to N. S., Que., and Man.; in Southeast (Map III), Ala., N. C., and Tenn.

SPECIMENS CITED: ALABAMA: Jackson, Harbison 4580 (NCU); Franklin (?), Baker, May 23, 1897 (NY, US); Madison, Baker, May 23, 1897 (NY). NORTH CAROLINA: Avery, Hunnewell 917 (GH); Caldwell, collector unknown, June 28, —— (NCU); Haywood, Holmes, Aug., 1903 (NCU); Jackson, Radford, May 29, 1947 (NCU); Macon, Radford 5255 (NCU); McDowell, Radford 5298 (NCU); Mitchell, Ashe, June 26, 1893 (NCU); Moore, Radford, 1950 (NCU); Polk, Peattie 2183 (NCU); Swain, Oosting 35259 (DUKE); Watauga, Radford 258C (NCU). TENNESSEE: Blount, Kinsey, May 1, 1932 (TENN); Davidson, Quarterman 1207 (DUKE); Knox, Sharp & Hesler 584 (TENN); Sevier, Sharp 646 (TENN); Unicoi, Price 939 (DUKE).

2. *Osmorhiza longistylis* (Torr.) D. C. (*O. longistylis* var. *villicaulis* Fern.) Smoother sweet Cicely, Sweet Anise, Anise-root, Sweet Chervil, Sweet Jarvil, Cicely root.

Plants up to 10 dm. tall; roots with anise odor; stems glabrous to densely villous; leaf blades thin, ovate or lanceolate, coarsely serrate, some incised; umbels fairly symmetrical in flower, but highly asymmetrical in fruit; rays 1–6; ovary and fruit elongate, strigose on base and ribs; fruit clavate or oblong-clavate, about 15–20 mm. long.—Native. Flowers in spring.

Varieties of this species have been described on the basis of degree of pubescence of stem. Because of the impossibility of drawing dividing lines, it seems best to consider the whole population as variable in this character.

DISTRIBUTION: Rich woods; Chiefly pied. and mts. in this area. Ga. to Tex., north to Que. and Alb.; in Southeast (Map III), Ga., Ala., N. C., and Tenn.

SPECIMENS CITED: ALABAMA: Tuscaloosa, Ward, April, 1892 (US); Walker, Harper & Morgan, April 30, 1941 (GH, US). GEORGIA: North Georgia, Vasey, 1876 (US); also, reported by Constance & Shan (Pyron & McVaugh 2494; GA). NORTH CAROLINA: Buncombe, Biltmore Herb. 674b (US); Chatham, Coker, Apr. 24, 1938 (NCU); Durham, Oosting 3318 (DUKE, PH); Mitchell, Ashe, June 26, 1893 (NCU); Orange, Browne, 1949 (NCU); Swain, Jennison 711 (TENN); Watauga, reported by Small & Heller. TENNESSEE: Davidson, Gattinger, June 28, 1886 (US); Decatur, Sharp, Felix, & Adams 12801 (TENN); Dyer, Sharp et al. 12233 (TENN); Knox, Ruth 429 (US); Louderdale, Sharp et al. 12130 (TENN); Loudon, Cain & Sharp 4506 (TENN); Obion, Eyles 7733 (GH); Tipton, Sharp et al. 12155 (TENN).

9. CHAEROPHYLLUM L. Chervils.

Glabrous or pubescent, branching, erect or ascending annuals or biennials. Taproots or tuberous roots. Leaves decompound. Umbels compound or simple, opposite leaves. Bracts absent in compound umbels, present in simple ones; bractlets present. Flowers perfect, regular. Calyx-teeth obsolete. Petals mostly white, spreading. Stamens and styles usually equal or shorter than petals. Stylopodium conic. Ovary and fruit elongate, laterally flattened; fruit ribbed. Carpophore split almost half way to base. Oil-tubes solitary between ribs, 2 on commissure. Strengthening cells conspicuous in primary areas. Seed subterete, face deeply sulcate.

Fruit contracted into a beak at its apex; ribs usually wider than the intervals between them; body of fruit usually 2 mm. or less wide; plants densely to sparingly hispid; ultimate segments of leaves acute and obtuse; bracts (bractlets if umbel compound) longer than shortest pedicels of mature fruits .... 1. *C. tainturieri*

Fruit not beaked at apex; body of fruit usually 2 mm. or more wide; plants glabrous or sparingly pubescent; ultimate segments of leaves mostly obtuse; all bracts (bractlets if umbel compound) shorter than pedicels of mature fruits .... 2. *C. procumbens*

1. *Chaerophyllum tainturieri* Hook. (*C. tainturieri* var. *floridanum* C. & R.; *C. floridanum* [C. & R.] Bush) Tainturier's Chervil.

Plants mostly erect, up to 9 dm. tall, hispid, especially at base; umbels usually simple, 1–4 at a node, if compounded, peduncles up to 5 cm.; petals not recurved at tips; ovary and fruit (Fig. 9) twice or more longer than wide, glabrous. —Native weed. Flowers in spring.

A variety of this species with pubescent fruits ranges from Ala. to Tex.

DISTRIBUTION: Waste-places; mts., pied., and coastal plain. Fla. to Tex., north to Va., Ind., and Kans.; in Southeast (Map IV), all states.

SPECIMENS CITED: ALABAMA: Hale, Harper 3196 (GH, PH); Choctaw, Mohr, May 16, 1898 (US); Lee, Earle & Baker, April 9, 1898 (US); Mobile, Mohr, April, 1879 (US); Tuscaloosa, Ward, April 7, 1892 (US). FLORIDA: Alachua, West, April 14, 1933 (FLA); Duval, Curtiss 4653 (GH, PH, US); Jackson, Biltmore Herb. 1912a (US); Leon, Kurz, May, 1943 (FLA); Manatee, Tracy 7442 (GH, PH, US); St. Johns, Curtiss 6134 (FLA, NCU); Volusia, Fuller, April 9, 1904 (GH); Washington, Plas, July 3, 1941 (FLA). GEORGIA: Baldwin, Duncan 1376 (FUR, PH); Clarke, Pyron, March 15, 1930 (DUKE); Cobb, Larrabee, May 3, 1885 (GH); De Kalb, Curtiss 6777 (GH, US); Dougherty, Thorne & Muenscher 2436 (US); Elbert, Duncan 9429 (GA, NCU); Fulton, Knowlton, April 20, 1905 (GH); Richmond, Cuthbert, April 1–23, 1904 (FLA). LOUISIANA: East Baton Rouge, Billings 46 (GH); Jefferson, Ball 314 (GH, NY, US); Natchitoches, Palmer 7488 (NY); Orleans, Meredith, April, 1916 (PH). MISSISSIPPI: Attala, McDougall 1245 (US); Hinds, Phares 2 (US); Oktibbeha, Tracy 1350 (US); Washington, Barnhart 2829 (NY). NORTH CAROLINA: Alamance, Rodgers 366C (NCU); Brunswick, Rodgers 318C (NCU); Columbus, Rodgers 272C (NCU); Craven, Rodgers 342AC (NCU); Cumberland, Rodgers 167C (GA, NCS, NCU); Durham, Rodgers 248C (NCU); Greene, Rodgers 845C (NCU); Guilford, Rodgers 372C (NCU); Halifax, Bartram(?), April 19, 1909 (PH); Harnett, Rodgers 121C (NCU, NY, US); Johnston, Rodgers 343C (NCU); Montgomery, Rodgers 461C (NCU); New Hanover, Oosting 3565 (DUKE, NY); Orange, Rodgers 19C (NCU); Pamlico, Rodgers 233AC (NCU); Pender, Rodgers 133C (NCU); Perquimans, Rodgers 552C (NCU); Pitt, Woods, May 9, 1949 (NCS); Polk, Peattie 1872 (NCU); Randolph, Rodgers 441C (NCU); Robeson, Rodgers 339C (NCU); Stanly, Kirk 41 (NCU); Tyrrell, Rodgers 513C (NCU); Vance, Fernald & Long 7919 (GH, NY, US); Wake, Rodgers 361C (NCU); Wayne, Rodgers 196C (NCU); Wilson, Rodgers 356C (NCU). SOUTH CAROLINA: Aiken, Ferguson, April 5, 1922 (NY); Anderson, Davis, April 5, 1920 (US); Beaufort, Churchill 612 (GH); Charleston, Hunt 220F (CLEMS); Colleton, Williamson, April, 1894 (PH); Darlington, Norton, April 29, 1921 (NCU); Greenville, Peattie, May 1, 1931 (FUR); Lexington, McGregor 519 (NCU); Oconee, Rosenkrans, April 29, 1930 (CLEMS); Richland, Crawford, June, 1891 (US). TENNESSEE: Anderson, Jennison 217 (TENN); Bedford, Montgomery, May 8, 1894 (GH, US); Blount, Jones 512 (TENN); Carroll, Sharp et al. 12148 (TENN); Davidson, Hubbard 1039 (US); Dyer, Sharp et al. 12208 (TENN); Fayette,

Sharp et al. 10363 (TENN); Franklin, Sharp et al. 10712 (TENN); Giles, Sharp et al. 10961 (TENN); Hamilton, Beckwith 930 (US); Haywood, Bain 413 (GH, NY); Henry, Sharp et al. 13065 (TENN); Knox, Sharp & Hesler 165 (TENN); Lewis, Sharp et al. 11911 (TENN); Montgomery, Shanks 1791 (TENN); Polk, Sharp et al. 10501 (TENN); Rutherford, Eggert, May 4, 1898 (US); Shelby, Moore T354 (TENN); Sumner, Deam, May 10, 1941 (DUKE); Wilson, Pennell 11378 (PH).

2. *Chaerophyllum procumbens* (L.) Crantz Spreading Chervil.

Plants tending to spread, up to 9 cm. tall; umbels simple, usually 2–3 from a node, or compound with slender peduncles; ovary and fruit twice or more longer than wide, glabrous.—Native weed. Flowers in spring.

This species' range is mostly north of N. C., but two collections are known from S. C., five from Tex., and one from Ala. No collection is yet known from this state.

DISTRIBUTION: Waste-places. S. C., Ala., Ark., and Kans., north to N. Y. and Ont.; in Southeast (Map IV), S. C., Ala., and Tenn.

SPECIMENS CITED: ALABAMA: Colbert, Harper, April 27, 1943 (US). MISSISSIPPI: Reported by Lowe. NORTH CAROLINA: Reported by Hyams. SOUTH CAROLINA: Charleston (?), Blackman, no number or date (PH); Chesterfield, Williamson, April 9, 1898 (PH). TENNESSEE: Davidson, Quarterman 769 (DUKE); Hardin, Felix et al. 10141 (TENN); Knox, Ruth 2859 (NY); Marshall, Sharp et al. 11202 (TENN); Rutherford, Sharp et al. 11820 (TENN).

10. CRYPTOTAENIA D. C.

Glabrous, erect, branching perennials. Taproots and fibrous roots. Leaves trifoliate. Umbels compound, asymmetrical, opposite leaves. Bracts absent or solitary; bractlets absent or 2–3. Flowers regular, perfect and staminate. Calyx-teeth absent to small. Petals white, recurved at tips. Stylopodium conic. Ovary and fruit elongate and laterally flattened; fruit ribbed. Carpophore split to base. Oil-tubes 1–4 between the ribs, 2 on commissure. Seed subterete.

1. *Cryptotaenia canadensis* (L.) D. C. (*Deringa canadensis* [L.] Kuntze) Honewort.

Plants up to 12 dm. tall; leaflets thin, ovate, elliptic, or lanceolate, acute at apexes, doubly serrate (tips of teeth acute to acuminate); terminal leaflets with cuneate-serrate bases; basal leaflets often deeply cut; sheath of leaves with hyaline margins; rays 1–7, very unequal; umbelets with 10 or fewer pedicels, very unequal, pedicels bearing staminate flowers much shorter; stamens slightly longer than petals; ovary almost twice as long as wide, smooth; fruit (Fig. 10) twice as long as wide or longer; ribs primary, alike.—Native. Flowers in spring and summer.

DISTRIBUTION: Wooded or open bottomland and hardwood forests; chiefly pied. and mts. Ga. to Tex., north to N. B., Que., and Man.; in Southeast (Map III), all states except Fla. (reported in Miss.).

SPECIMENS CITED: ALABAMA: Coosa, Earle, Aug. 29, 1897 (NY); Tuscaloosa, Harper 3073 (GH, NY). FLORIDA: None. GEORGIA: Cherokee, Duncan 8331 (FLA); Clarke, Pyron, July 13, 1929 (DUKE); Early, Harper 1228 (GH, NY, US); Lincoln, Duncan 9826 (GA); Richmond, Cuthbert, July 27, 1900 (NY); Whitfield, Harper 249 (GH, NY, US). LOUISIANA: East Baton Rouge, Brown 2805 (GH); Feliciana (East or West ?), Carpenter, June, 1890 (US); Rapides, Hale, no number or date (NY). MISSISSIPPI: Reported by Lowe. NORTH CAROLINA: Alamance, Oosting 33538 (DUKE); Buncombe, Rodgers 707C (GA, NCU); Cabarrus, Rodgers 770C (DUKE, NCU); Caldwell, Rodgers 837C (NCU); Caswell, Rodgers 387C (NCU); Catawba, Correll 2834 (DUKE); Chatham, Rodgers 436AC (NCU); Cherokee, Oosting 34609 (DUKE, PH); Davidson, Totten, June 17, 1931 (NCU); Davie, Rodgers 759C (NCU); Durham, Coker & Totten, June 26, 1915 (NCU); Forsyth, Rodgers 378C (NCU); Franklin, Rodgers 423C (NCU); Granville, Godfrey, Aug. 11, 1938 (NCU); Guilford, Rodgers 370C (GA, NCU); Halifax, Rodgers 416C (NCU, NY); Haywood, Caughey 759 (DUKE); Iredell, Rodgers 756C (NCU); Jackson, Radford, June 25, 1946 (NCU); Johnston, Fox & Godfrey 2438 (NCS); Macon, Radford, June 22, 1946 (NCU); Madison, Rodgers 691C (NCU); McDowell, Rodgers 716C (DUKE, NCU, NY, US); Moore, Fox & Godfrey 2438 (NCS); Montgomery, Rodgers 462AC (NCU); Orange, Rodgers 486C (NCU); Person, Rodgers 395C (NCU); Polk, Peattie 1031A (NCU); Randolph, Rodgers 442C (NCU); Richmond, Rodgers 581C (NCU); Stokes, Oosting 1961 (DUKE); Swain, Oosting 35250 (DUKE); Union, Correll 944 (DUKE); Wake, Rodgers 426C (NCU); Watauga, Rodgers 816C (DUKE, GA, NCU); Yadkin, Oosting 33493 (DUKE); Yancey, Radford, July 9, 1946 (NCU). SOUTH CAROLINA: Marlboro, Radford & Stewart 412 (NCU). TENNESSEE: Anderson, Cole 758 (TENN); Blount, M. B. H. 1703 (TENN); Carroll, Svenson 364 (GH); Cheatham, Svenson 10353 (GH); Cocke, Jennison 322 (TENN); Davidson, Svenson 79 (GH); Grainger, Morrison & Brown, Aug. 12, 1936 (TENN); Hardeman, Sharp et al. 122 (TENN); Haywood, Bain 414 (GH, NY); Knox, Hesler 1652 (NY); Montgomery, Clebsch, May 26, 1946 (TENN); Sevier, Jennison 2364 (TENN); Sullivan, Sharp & J. K. U. 1516 (TENN); Unicoi, Price 753 (DUKE).

11. CORIANDRUM L. Corianders.

Glabrous, erect, branching annuals. Taproots. Leaves variable, mostly decompound. Umbels compound, opposite leaves. Bracts mostly absent; bractlets absent or simple and narrow; Flowers perfect and staminate, some distinctly irregular. Calyx-teeth distinct, often unequal. Petals white or pinkish, spreading, recurved at tips; Stylopodium conic. Ovary laterally flattened. Fruit (Fig. 11) globose, ribbed; mericarps not separating at maturity. Carpophore entire. Seed dorsally flattened, face concave.

1. *Coriandrum sativum* L. Coriander.

Plants up to 9 dm. tall, slender; lower leaves simple, trifoliate, or pinnate; upper leaves much dissected with ultimate divisions mostly linear; sheaths of petioles with hyaline margins; rays 2–8; radiant petals deeply bilobed and with obvious branching veins; fruit (Fig. 11) 1.5–5 mm. broad and tall; primary ribs wavy, secondary (6) straight, both narrow and filiform.—Introduced crop plant. Fruits used medicinally and for flavoring.

DISTRIBUTION: Waste-places throughout U. S.; seldom seen in Southeast (Map IV).

SPECIMENS CITED: NORTH CAROLINA: Iredell, Hyams, Aug., 1897 (US). TENNESSEE: Davidson, Gattinger, no number (US).

12. CONIUM L.

Glabrous (glaucous when young), tall, branching biennials; Taproots. Stem purple-spotted. Leaves decompound, the segments narrow. Umbels compound, opposite leaves, terminal on axillary branches, or cymose. Bracts and bractlets simple. Flowers irregular. Calyx-teeth obsolete. Petals white, spreading, recurved at tips. Stylopodium low-conic. Ovary and fruit laterally flattened and with wavy ribs. Carpophore split to base. Oil-tubes absent or irregular and small (not visible without magnification). Seed nearly terete, face deeply sulcate (Fig 12).

1. *Conium maculatum* L. Poison Hemlock, Snakeweed, Poison Parsley, Spotted Parsley, Winter Fern.

Plants with strong, offensive odor, up to 30 dm. tall; leaves fern-like; rays 12–18; umbelets with 17–20 flowers; stamens longer than petals, maturing before pistil; fruit broadly ovoid (Fig. 12).—Introduced. Very poisonous, especially fruits; extract from fruits used medicinally. Flowers in spring and summer.

The poisonous nature of this plant is well known to many people because a drink prepared from it was used to kill Socrates. In spite of its deadliness and foul odor, it is occasionally tolerated enough for it to become well established. A particularily impressive display of this plant can be seen between Bakersville and Red Hill in Mitchell Co. For over 3 miles along a stream it is taking over the bottomland.

DISTRIBUTION: Waste-places throughout N. A.; in Southeast (Map VIII).

SPECIMENS CITED: ALABAMA: Mobile, Mohr, June, 1896 (US). FLORIDA: Escambia, Tracy 8435 (GH, NY, US). NORTH CAROLINA: Durham, Beers, 1950 (NCU); Guilford, Rodgers 375C (GA, NCU); Mitchell, Rodgers 839C (DUKE, GA, NCS, NCU, NY, US). SOUTH CAROLINA: Charleston, Hunt 1474 (CLEMS). TENNESSEE: Unicoi, Shanks 3026 (TENN).

13. ERIGENIA Nutt.

Low, glabrous perennials. Deep globular tubers, about 1 cm. in diameter. Leaves ternately decompound. Umbels compound; rays 1–4. Bracts 1–2 and foliaceous or absent; bractlets mostly spatulate and mostly equaling or exceeding flowers and fruits. Flowers regular. Calyx-teeth obsolete. Petals white, spreading, not recurved at tips. Stylopodium absent. Ovary and fruit laterally flattened; mericarps of fruit separating in middle. Carpophore absent. Oil-tubes small, 1–3 between ribs, several on commissure. Seed laterally flattened, face deeply sulcate (Fig. 13).

1. *Erigenia bulbosa* (Michx.) Nutt. Harbinger-of-spring, Turkey pea, Pepper-and-salt.

Plants up to 20 cm. tall; leaves few, ultimate divisions mostly mucronate; sheaths of leaves with hyaline margins; rays 1–4, up to 2.5 cm. long; stamens a little longer than petals; styles about length of petals; fruit (Fig. 13) 2.5–5 mm. broad and 2–3 mm. tall; styles long, recurved in fruit; ribs primary, filiform, alike.—Native. Flowers in spring.

DISTRIBUTION: Open, rich woods. Ala., Ark., and Kans., north to N. Y. and Ont.; in Southeast, most abundant in Tenn., reported in mts. of N. C. by Kephart and Hyams.

SPECIMENS CITED: ALABAMA: Madison, Wells, 1840 (NY); Morgan, Peters, April, 1864 (NY); Tuscaloosa, Harper, 1932 (GH, NY). MISSISSIPPI: Reported by LOWE. NORTH CAROLINA: Reported in mts. by Hyams & Kephart. TENNESSEE: Bledsoe, Iltis 3194 (TENN); Davidson, Sharp & Bold 65 (TENN); Hardin, Sharp et al. 10104 (TENN); Franklin, Svenson 7560 (GH); Knox, Jennison 4002 (TENN); Lincoln, Sharp et al. 10843 (TENN); Obion, Sharp et al. 12307 (TENN); Putnam, Cain & Sharp 4381 (TENN); Shelby, Sharp et al. 10426 (TENN); Tipton, Sharp et al. 12035 (TENN); Van Buren, Shanks, March 7, 1948 (TENN).

14. FOENICULUM Adans.

Glaucous to glabrous, tall, branching biennials or perennials with strong anise odor. Taproots. Leaves dissected into filiform segments. Umbels compound, opposite bract-like leaves or cymose. Bracts and bractlets absent. Flowers regular. Calyx-teeth obsolete. Petals yellow, spreading, the tips rolled inward. Stylopodium conic, yellow. Ovary slightly laterally flattened. Fruit elongate, slightly laterally flattened, ribbed (Fig. 14). Carpophore split to base. Oil-tubes solitary between ribs, 2 on commissure. Seed dorsally flattened (Fig. 14).

1. *Foeniculum vulgare* Mill. (*F. foeniculum* Karst.) Fennel.

Plants perennial, up to 21 dm. tall; stem green; rays 7–40 (usually 10–20); stamens yellow, more than twice length of petals; styles very short; stylopodium yellow; fruit oblong-ellipsoid, almost twice as long as wide; ribs primary, alike

(Fig. 14).—Introduced crop plant. Fruits used medicinally and for flavoring. Flowers in summer and fall.

DISTRIBUTION: Open places; mts., pied., and coastal plain. Throughout U. S.; in Southeast (Map VIII).

SPECIMENS CITED: ALABAMA: Location unknown, Rhodes, Aug., 1927 (NY). FLORIDA: Duval, Lighthipe 284 (NY); Volusia, Robertson, Aug. 1, 1942 (FLA). GEORGIA: Clarke, Pyron, July 5, 1929 (DUKE); Glenn, McAtee 3278 (US). LOUISIANA & MISSISSIPPI: None. NORTH CAROLINA: Buncombe, Biltmore Herb. 442 (US); Carteret, Grady 71 (DUKE); Chatham, Rodgers 432 (NCU); Currituck, Rodgers 530C (NCU); Davidson, Rodgers 446C (GA, NCU); Forsyth, Schallert 1098 (DUKE); Guilford, Rodgers 780C (DUKE, NCU); Henderson, Rodgers 681C (DUKE, GA, NCS, NCU, US); Hyde, Rodgers 521C (NCU); Iredell, Hyams, June, 1818 (NY, US); Macon, Rodgers 632C (NCU); New Hanover, Biltmore Herb., July 16, 1897 (US); Onslow, Rodgers 861C (NCU); Orange, Rodgers 392C (NCU); Rowan, Heller, Aug. 25, 1890 (NY, PH); Transylvania, Godfrey & Fox 3019 (US). SOUTH CAROLINA: Beaufort, Cuthbert, June, 1884 (FLA); Charleston, Hunt 2211 (CLEMS); Greenwood, Cox, July 6, 1935 (FUR); York, Biltmore Herb. 442C (US). TENNESSEE: Blount, Burns, Oct. 2, 1936 (NCS); Knox, Ruth 421 (US).

15. PETROSELINUM Hoffm.

Glabrous, erect, branching annuals, biennials, or perennials. Taproots or fibrous roots. Leaves decompound; leaflets flat or crisped. Umbels compound, opposite leaves or cymose. Bracts few and simple, their margins hyaline, or bracts absent; bractlets several, their margins hyaline. Flowers nearly regular, perfect and staminate. Calyx-teeth obsolete. Petals yellow, spreading, recurved at tips. Stylopodium large, conic. Ovary laterally flattened. Fruit laterally flattened, ribbed; mericarps separating in middle. Seed nearly terete.

Leaf blades crisped .... 1. *P. crispum*
Leaf blades flat .... 1a. *P. crispum* var. *latifolium*

1. *Petroselinum crispum* (Mill.) Mansf. (*Apium petroselinum* L.) Parsley.

Plants up to 13 dm. tall; sheaths of leaves with hyaline margins; petals greenish-yellow or yellow; styles short; fruit (Fig. 15) oblong-ellipsoid, 2–6 mm. long; ribs primary, alike.—Introduced crop plant. Leaves used to flavor or garnish foods; fruits used medicinally and for seasoning. Flowers in late spring and summer.

DISTRIBUTION: Waste-places throughout U. S., but seldom seen in Southeast.

SPECIMENS CITED: GEORGIA: Clarke, Harper 2315 (NY, US). NORTH CAROLINA: Iredell, Hyams 4963 (NY). SOUTH CAROLINA: Darlington, Norton, April 20, 1921 (US).

1a. *Petroselinum crispum* var. *latifolium* Airy-Shaw.

This variety is cultivated to some extent in North Carolina, but most people plant the species because the crisped leaves are considered more desirable.

16. BUPLEURUM L.

Glabrous or glaucous annuals or perennials. Taproots. Leaves entire; stem leaves usually perfoliate or clasping. Umbels compound, opposite the leaves. Bracts absent or conspicuous and leafy; bractlets whorled, broad and conspicuous. Flowers regular, perfect. Calyx-teeth obsolete. Petals yellow, recurved at tips. Stylopodium conic. Ovary and fruit weakly laterally flattened, smooth to tuberculate, filiform-ribbed. Carpophore split to base. Oil-tubes various. Seed subterete.

1. *Bupleurum rotundifolium* L. Thorough-wax, Hare's Ear, Modesty.

Herbaceous annuals up to 10 dm. tall, usually branching above; leaves ovate to elliptic, entire, upper ones perfoliate, but lower ones usually clasping; rays of umbel 3–10, longest 14 mm.; bracts absent; bractlets 5–6 in whorl, ovate, elliptic, or obovate, entire, longer than flowers and fruits; stamens about length of petals; styles short; fruit (Fig. 16) ellipsoid to ovoid, 2–3.5 mm. long, dark-colored; ribs alike.—Introduced.

DISTRIBUTION: Waste-places. N. C. to Tex., north to N. Y. and S. D. (Small also gives Ariz.); in Southeast (Map II), N. C., Tenn., and reported from Ala.

SPECIMENS CITED: ALABAMA: Reported by Mohr and Harper (Green & Tuscaloosa Cos.). NORTH CAROLINA: Orange, Ashe, no number or date (US); Rowan, Heller 62 (NY, PH). TENNESSEE: Davidson, Gattinger, 1876 (GH, NY); Knox, Ruth 2857 (NCU); Rutherford, Quarterman 1616 (DUKE); Wilson, Sharp 1558 (TENN).

17. TAENIDIA Drude

Glabrous or glaucous, erect, branching perennials. Fleshy taproots. Leaves ternately or ternate-pinnately decompound; leaflets broad and entire, occasionally variously cut. Umbels compound, opposite leaves; oldest umbel tending to be predominantly staminate. Bracts and bractlets absent. Flowers regular, perfect and staminate. Calyx-teeth small or absent. Petals yellow, recurved at tips. Stylopodium absent. Ovary and fruit laterally flattened, ribbed. Carpophore split almost to base. Oil-tubes numerous between ribs and on commissure. Seed subterete.

1. *Taenidia integerrima* (L.) Drude (*Pimpinella integerrima* A. Gray) Yellow Pimpernels, Golden Alexanders.

Plants aromatic, up to 9 dm. tall; leaflets ovate, lanceolate, elliptic, or obovate, apex obtuse, obtuse-mucronate, or acute, base oblique, rounded, cuneate, or

cordate; rays 1–20, slender, spreading, unequal, up to 9.5 cm. long; mixed umbelets usually having outside flowers perfect and center ones staminate; pedicels of fruits up to 12 mm. long, slender, spreading, unequal, about twice length of pedicels of sterile flowers: stamens and styles twice length of petals; fruit (Fig. 17) ovoid or broadly ellipsoid, 3–4 mm. long; ribs primary, alike.—Native. Flowers in spring.

DISTRIBUTION: Woods, dry banks and hillsides; mostly pied. and mts. Ga. to Tex. (Cory 22866, GH), north to Que. and Ont. (Macoun, 1901; GH); in Southeast (Map X), all states except Fla. and Miss. (probably present).

SPECIMENS CITED: ALABAMA: Clarke, Porter, June 15, 1934 (GH); Madison, Mohr, May 30, 1891 (US). FLORIDA: None. GEORGIA: Catoosa, Cronquist 5400 (US); Elbert, Duncan 9431 (GA, NCU); Fulton, Harper 1275 (GH, NY, US); Lumpkin, Leeds 2066 (PH); Meriwether, Tracy 8918 (GH, NY, US); Pike, Cronquist 5485 (GH, US); Richmond, Cuthbert 660 (FLA, NY); Whitfield, Harper 298 (NY, US). LOUISIANA: Natchitoches, Palmer 7297 (NY). MISSISSIPPI: None. NORTH CAROLINA: Alamance, Totten, May 22, 1937 (NCU); Alexander, Keever 338 (DUKE); Buncombe, Biltmore Herb. 4350a (GH, NCU, NY, US); Burke, Small & Heller (NY, PH, US); Durham, Blomquist 4420 (DUKE); Jackson, Oosting 497a (DUKE); Madison, Churchill, June 7, 1899 (TENN); Mitchell, Ashe, May 25, 1893 (NCU); Orange, Rodgers 391C (GA, NCS, NCU); Polk, reported by Peattie; Wake, Ashe, May 10,—— (NCU). SOUTH CAROLINA: Pickens, Rodgers 536 (DUKE); Richland, Coker, April 5, 1935 (NCU). TENNESSEE: Anderson, Jones, April 22, 1935 (TENN); Bledsoe, Shanks et al. 4441 (TENN); Blount, Sharp 1026 (TENN); Cocke, Kearney 700 (NCU, NY, US); Franklin, Svenson 10242 (GH); Grainger, Jennison & Wilson, April 25, 1934 (TENN); Knox, Ruth 423 (NY); Marion, J. K. U. et al. 2479 (TENN); Monroe, Sharp 692 (TENN); Montgomery, Clebsch, April 24, 1946 (TENN); Sevier, Cain & Duncan 246:2 (TENN); Unicoi, Price 916 (DUKE); Union, Kalter, June 24, 1936 (TENN).

18. THASPIUM Nutt. Meadow Parsnips.

Glabrous or pubescent, erect, branching perennials. Roots fibrous, somewhat fleshy. Leaves simple to decompound. Umbels compound, opposite leaves and cymose; oldest umbel tending to be predominantly staminate. Bracts absent to few, inconspicuous; bractlets few, simple. Flowers regular, perfect and staminate. Calyx-teeth present or obsolete. Petals yellow or purple, erect, recurved at tip. Stylopodium absent; disk present. Ovary laterally flattened, ribbed. Fruit laterally flattened, some or all ribs extended as wings (Fig. 18), mericarps not separating at maturity. Carpophore obscure or distinct and split almost to base. Oil-tubes solitary between ribs, 2 on commissure. Seed slightly dorsally flattened, sulcate under oil tubes (Fig. 18).

Leaves simple or ternate (sometimes biternate or pinnate above).
  Flowers purple...1. *T. trifoliatum*
  Flowers yellow...1a. *T. trifoliatum* var. *flavum*

Leaves decompound.
Ovary and fruit glabrous between wings; blades coarsely serrate and irregularly cut
2. *T. barbinode*
Ovary and fruit puberulent between wings; blades deeply cut into narrow segments
3. *T. pinnatifidum*

1. *Thaspium trifoliatum* (L.) A. Gray Purple Meadow Parsnip.

Plants always glabrous, sparingly branched, up to 7 dm. tall; leaves simple cordate, ternate, biternate, or pinnate, often 2 or more of these types on same plant; cordate leaves occurring anywhere on plant, usually at base, sometimes absent; blades ovate or lanceolate, mostly acute, margins crenate, crenate-serrate, or serrate; terminal leaflet of trifoliate leaves (when present) tending to be truncate at base and long-petiolulate; umbels usually 1–3 to a main stem, opposite leaves; rays 5–12, longest usually under 2.5 cm.; fruits oblong-ellipsoid, about 4 mm. long, all ribs winged.—Native. Flowers in spring and summer.

DISTRIBUTION: Deciduous woods and stream banks; mts., pied., and coastal plain. Fla. to La., north to R. I. and Man.; in Southeast (Map IX), all states.

SPECIMENS CITED: ALABAMA: Dallas, Harper 3819 (GH, NY); Hale, Mohr, June, 1892 (US); Franklin, Harper 3819 (GH, NY); Lee, Earle & Baker, March 29, 1898 (PH); Talladega, Harper 78 (NY); Tuscaloosa, Harper 3723 (NY). FLORIDA: Gadsden, Curtiss, May 7, 1898 (NY). GEORGIA: Columbia, Duncan 9774 (GA); Clarke, Harper 10 (US); Early, Thorne 4973 (GA, US); Pauling, Harper 81 (NY); Pulaski, Harper 1386 (GH, NY); Richmond, Harper 1318 (GH, NY); Sumter, Harper 1050 (GH). LOUISIANA: Orleans, Drummond 128 (GH). MISSISSIPPI: Choctaw, Clute, April 28, 1899 (NY). NORTH CAROLINA: Buncombe, Biltmore Herb. 1391b (GH, NCU, NY, US); Clay, Radford, Sept. 2, 1948 (NCU); Durham, Blomquist 7554 (DUKE); Forsyth, Schallert, April 20, 1940 (GH, NY); Guilford, Wiegand & Manning 2310 (GH); Haywood, Caughey 553 (DUKE); Iredell, Veerhoff 237 (NCS); Jackson, Radford, May 29, 1947 (NCU); Johnston, Fox & Godfrey 1667 (NCS); Macon, Radford, May 31, 1947 (NCU); Pender, reported by Curtiss; Polk, Townsend, May 17, 1897 (US); Swain, Oosting 35440 (DUKE); Wake, Wiegand & Manning 2310 (GH). SOUTH CAROLINA: Abbeville, Hexamer & Maier, no number or date (GH); Aiken, Ravenel, no number or date (NY); Anderson, Gibbs, 1886 (NY); Oconee, Rice, April 29, 1930 (CLEMS); Pickens, House 2160 (PH, US). TENNESSEE: Bledsoe, Harger 7714 (TENN); Bradley, Hester & Sharp 992 (TENN); Claiborne, Talcott 1889 (US); Cocke, Kearney 704 (NY, US); Davidson, Svenson & Shaver 9622 (GH, TENN); Jackson, Bain 411 (NY); Knox, Ruth, June, 1897 (NY); Maury, Weatherby 6343 (GH, TENN); Roane, Pollard & Maxon 415 (US); Union, Morrison, June 14, 1937 (TENN).

1a. *Thaspium trifoliatum* var. *flavum* Blake (*T. trifoliatum* var. *aureum* Brit.) Yellow Meadow Parsnip.

This plant differs from the species in having yellow flowers. It is often confused with *Zizia aptera*.

DISTRIBUTION: Deciduous woods and stream banks; mts., pied., and coastal plain. Fla. to La., and Okla., north to Penn. and Ont.; in Southeast (Map IX), all states.

SPECIMENS CITED: ALABAMA: Franklin, Harper 3819 (US); Lee, Earle, May 18, 1901 (NY); Talladega, Harper 78 (US). FLORIDA: Liberty, Beck, March 17, 1949 (FLA). GEORGIA: Clarke, Harper 145 (US); Columbia, Duncan 774 (GA, NCU); Pulaski, Harper 1386 (US); Rabun, Radford, May 31, 1947 (NCU); Richmond, Harper 1318 (US); Sumter, Harper 1050 (NY, US). LOUISIANA: St. Tammany, Arsene 12391 (US). MISSISSIPPI: Grenada, Millsaps, May 15, 1932 (NCU); Oktibbeha, Phares 7 (US). NORTH CAROLINA: Alamance, Rodgers 364C (NCU); Avery, Kelsey, Sept., 1890 (US); Buncombe, Rodgers 706C (NCS, NCU, NY, US); Chatham, Rodgers 223C (DUKE, NCU); Harnett, Rodgers 114C (NCU); Haywood, reported by Radford; Johnston, Mitchell, May 20, 1936 (DUKE); Macon, Radford, May 31, 1947 (NCU); Mitchell, Ashe, May 8, 1893 (NCU); Moore, Fox & Godfrey 1370 (NCS); New Hanover, reported by Wood & McCarthy; Orange, Rodgers 108C (NCU); Polk, reported by Peattie; Swain, Beardslee & Kofoid 4000 (TENN). SOUTH CAROLINA: Aiken, Ravenel, Sept., 1869 (US); Greenville, collector unknown, June 30 1937 (FUR). TENNESSEE: Bledsoe, Harger 7775 (GH); Blount, Jennison 41 (TENN); Hardeman, Sharp et al. 12689 (TENN); Knox, Ruth 425 (GH, NY); Lewis, Sharp et al. 10085 (TENN); Montgomery, Clebsch, March 30, 1946 (TENN); Sevier, Cain & Duncan 391:2 (TENN); Shelby, Sharp et al. 10486 (TENN); Sumner, Gattinger, 1883 (GH); Tipton, Sharp et al. 12148 (TENN).

2. *Thaspium barbinode* (Michx.) Nutt. Hairy Golden Alexander, Hairy-jointed Parsnip, Hairy-jointed Meadow Parsnip.

Plants loosely branching, usually pubescent at nodes, up to 12 dm. tall; leaves biternate, triternate, or ternate-pinnate (to simple ternate above); leaflets ovate or elliptic, acute at apex; umbels mostly cymose, occasionally opposite leaves; rays 5–15, mostly 2 cm. or shorter; umbelets with perfect flowers on outside and staminate ones in center; calyx-teeth triangular; styles longer than petals; fruit (Fig. 18) subellipsoid, about 6 mm. long; seven ribs usually extended as wings (4 laterals, 1 dorsal, and 2 intermediates); carpophore split almost to base.—Native. Flowers in spring and summer.

DISTRIBUTION: Rich woods and stream banks; mts., pied., and coastal plain. Fla., Ala., and Okla., north to N. Y. and Ont.; in Southeast (Map IX), all states except La. and Miss. (reported).

SPECIMENS CITED: ALABAMA: Clarke, Harper 3375 (GH, NY, PH, US); Jackson, Porter, June 11, 1934 (GH); Lee, Earle & Baker, May 29, 1897 (NY); Madison, Pollard & Maxon 365 (NY); Walker, Harper 329 (US). FLORIDA: Duval, Curtiss 1023 (NY); Walton, Curtiss, summer 1885 (NY). GEORGIA: Burke, Leeds & Harper 2762 (PH); Cobb, Perry & Myers 958 (GH, NY); Columbia,

Smith, July 7, 1890 (NY, US); Lincoln, Duncan 10018 (GA, NCU); Lumpkin, Pyron & McVaugh 2897 (US); Pickens, Leeds 2126 (DUKE); Randolph, Harper 2230 (GH, NY, US); Walker, Harper 329 (NY). LOUISIANA: None. MISSISSIPPI: Reported by Lowe. NORTH CAROLINA: Ashe, Fox 2472 (NCS); Buncombe, Caughey 219 (DUKE); Caldwell, Radford & Stewart 1580 (NCU); Catawba, Churchill, June 13, 1899 (GH); Chatham, Rodgers 78C (NCU); Davidson, Totten, June 17, 1931 (NCU); Durham, Sample 7 (DUKE); Forsyth, Rodgers 783C (NCU); Gaston, Rodgers 742C (NCU); Granville, Rodgers 402C (NCU); Haywood, Caughey 548 (DUKE); Henderson, Fox et al. 2210 (NCS); Iredell, Veerhoff, May 26, 1935 (NCS); Jackson, Radford, June 26, 1946 (NCU); Madison, Beaver 265 (DUKE); McDowell, Peattie 941 (NCU); Mecklenburg, Curtis, no number or date (NY); Mitchell, Merriam, Aug. 8, 1892 (US); New Hanover, reported by Wood & McCarthy; Orange, Rodgers 100C (NCU); Polk, Townsend, June 17, 1897 (US); Rockingham, Rodgers 384C (NCU); Surry, Rodgers 789C (NCU); Swain, Fox et al. 2181 (GA); Vance, Rodgers 408C (NCU); Wake, Godfrey 3403 (GH, NCS); Watauga, Radford 259C (NCU). SOUTH CAROLINA: Beaufort, Mellichamp, 1878 (GH, NY); Berkeley, Moldenke 1226a (DUKE, NY); Darlington, Smith, May 15, 1941 (NCU); Dorchester, Hunt 1661 (CLEMS); Georgetown, Godfrey & Tryon 1483 (US); Greenville, Thomason, April 30, 1935 (FUR); Oconee, House 2973 (US); Orangeburg, Godfrey & Tryon 1493 (DUKE, GH, NY, TENN); Pickens, House 2411 (US); Richland, Philson, April 23, 1936 (DUKE). TENNESSEE: Bledsoe, Shanks et al. 4429 (TENN); Blount, Godfrey, April 21, 1934 (TENN); Carter, Brown 28 (DUKE); Chatham, Svenson 10293 (DUKE); Cocke, Kearney 703 (US); Dickson, Svenson 4392 (GH); Franklin, Svenson 10179 (DUKE); Grainger, Morrison, July 23, 1936 (TENN); Knox, Ruth 213 (GH, NY); Polk, Sharp et al. 10528 (TENN); Sevier, Anderson 839 (GH); Sullivan, Vail, May 24, 1892 (NY); Unicoi, Price 711 (DUKE); Union, Kelly 2448 (TENN); Van Buren, Sharp et al. 11455 (TENN); Warren, Sharp et al. 11266 (TENN); Wayne, Sharp et al. 10187 (TENN).

3. *Thaspium pinnatifidum* (Buckl.) A. Gray Cut-leaved Meadow Parsnip.

Plants pubescent (especially at nodes), branching, up to 6 dm. tall; umbels cymose and opposite leaves; styles about length of petals; fruit subellipsoid, 3–4 mm. long, ribs all winged, shallow.—Native. Flowers in spring and summer.

DISTRIBUTION: Rich woods and along streams in mts. Ala. (reported), Tenn., Ky., and N. C. (Map IX).

SPECIMENS CITED: ALABAMA: De Kalb (LOOKOUT MT.), reported by Mohr. NORTH CAROLINA: Macon, Rugel, Sept., 1842 (GH); Madison, Churchill, June 3, 1899 (GH, TENN); Swain, Beardslee & Kofoid, Aug. 1, 1891 (GH, NY, US). TENNESSEE: Cocke, Sharp 1417 (TENN).

19. ZIZIA Koch Meadow Parsnips.

Glabrous or pubescent, erect perennials. Roots fibrous, somewhat fleshy. Leaves simple to decompound; blades broad. Umbels compound, opposite leaves

or rarely cymose; oldest umbel predominantly staminate. Bracts absent or few and simple; bractlets simple. Flowers regular, perfect (sessile if in center of umbelet) and staminate. Calyx-teeth absent or distinct. Petals yellow, erect, recurved at tips. Stylopodium absent; disk present. Ovary and fruit laterally flattened, ribbed. Ribs filiform, alike. Carpophore split ½ or all way to base. Oil-tubes solitary between ribs, 2 on commissure. Seed subterete, sulcate under oil-tubes.

Basal leaves simple cordate or trifoliate....................................1. *Z. aptera*
Basal leaves with more than 3 blades or if 3 blades, the terminal leaflet deeply cut into 3 parts and leaves appearing 5-foliate.
  Basal leaves usually with 5 or more leaflets; leaf blades uniformly fine-serrate; rays short, longest usually about 2.5–3.5 cm. long, rarely up to 5.5 cm., in fruit and 1–1.5 cm. long in flower....................................2. *Z. aurea*
  Basal leaves mostly 3-foliate or appearing 5-foliate if terminal leaflet deeply cut into three parts, rarely 5-foliate or more; leaf blades usually crenate-serrate; rays long, longest usually 4–5 cm. long, rarely up to 8 cm., in fruit and usually 2–4.5 cm. long in flower....................................3. *Z. trifoliata*

1. *Zizia aptera* (A. Gray) Fern. (*Z. cordata* [Walt.] D. C.) Heart-leaved Alexander, Golden Parsnip.

Plants pubescent or glabrous, sparingly branched, up to 6 dm. tall; stem leaves mostly trifoliate; leaflets ovate, lanceolate, and oblanceolate, margins crenate, crenate-serrate, dentate, or serrate, sometimes cut; terminal leaflet usually tapering to base; umbels mostly 1–5; rays 3–16, up to 3.5 cm. long; fruit (Fig. 19) broadly ellipsoid, about 3 mm. long.—Native. Flowers in spring and summer.

This plant is commonly confused with *Thaspium trifoliatum* var. *flavum*.

DISTRIBUTION: Rich woods; chiefly pied. and mts. Ga., Ala., Colo., Utah, and Ore., north to Can.; in Southeast (Map X), Ala., Ga., S. C., N. C., and Tenn.

SPECIMENS CITED: ALABAMA: Henry, Wiegand & Manning 2311 (GH); Jackson, Harper 3923 (GH, US); Lee, Earle & Baker, May 7, 1898 (US). FLORIDA: None. GEORGIA: Clarke, Pyron, April 16, 1930 (DUKE); Catoosa, Churchill, May 25, 1911 (GH); Haralson, Way 28 (US); Lumpkin, Leeds 2067 (PH); Madison, Harper 1501 (PH); Rabun, Cronquist 5538 (GH, US); Richmond, Cuthbert, April 16, 1902 (FLA). LOUISIANA & MISSISSIPPI: None. NORTH CAROLINA: Buncombe, Ashe, Aug. 31, 1892 (NCU); Burke, Rodgers 728C (NCU); Caldwell, Blomquist 13861 (DUKE); Chatham, Rodgers 227C (NCU); Clay, Rodgers 614 (NCU, US); Durham, Oosting 2245 (DUKE); Forsyth, Schallert 14664 (NCU); Halifax, Bartram, April 19, 1908 (GH); Henderson, Garren 218 (DUKE); Jackson, Radford, May 29, 1947 (NCU); Macon, Radford, May 31, 1947 (NCU); Mecklenburg, Brimley, April 13, 1922 (NCS); Mitchell, Ashe, June, 1893 (NCU); Moore, Godfrey et al. 49141 (NCS); Orange, Rodgers 101C (NCU); Polk, Peattie 2202 (NCU); Richmond, Williamson, April 15, 1895 (PH); Rowan, Heller 63 (NY, PH);

Swain, Beardslee & Kofoid, Aug. 20, 1891 (PH); Warren, Godfrey 3636 (GH); Wake, Godfrey 3687 (NCU). SOUTH CAROLINA: Darlington, Norton, April 26, 1921 (NCU); Greenville, Fallaw, no number or date (FUR); Richland, Philson, April 23, 1936 (DUKE). TENNESSEE: Anderson, Varnell, April 24, 1937 (TENN); Bledsoe, Harger 7775 (TENN); Campbell, Hesler et al. 2246 (TENN); Carter, Rydberg 8185 (NY); Fentress, Shanks 1525 (TENN); Hamilton, Pollard & Maxon 421 (US); Knox, Ruth, June, 1893 (PH); Marion, Sharp et al. 10671 (TENN); Sevier, Anderson & Jennison 872 (GH); Van Buren, Shanks 3373 (TENN).

2. ***Zizia aurea*** (L.) Koch Golden Meadow Parsnip, Golden Alexander, Early Meadow Parsnip, Wild Parsley.

Plants glabrous, up to 8 dm. tall; leaflets ovate, lanceolate, or elliptic, acute at apex, cordate, truncate, cuneate, or oblique at base; umbels mostly 3–10; rays 4–15; fruit oblong-ellipsoid to oblong-ovoid, about 4 mm. long.—Native. Flowers in spring and summer

DISTRIBUTION: Low woods and meadows, often by streams; mts. and pied., sometimes coastal plain. Fla. to Tex., north to Que. and Sask.; in Southeast (Map X), all states.

SPECIMENS CITED: ALABAMA: Chilton, Harper 3175 (NY); Clay, Earle, Aug. 28, 1897 (NY); Cullman, Harbison 4212 (NCU); Tuscaloosa, Harper 3723 (US). FLORIDA: Alachua, Murrill, April 13, 1940 (DUKE); Gadsden, Curtiss, May 7, 1898 (NY). GEORGIA: Bibb, Small, May 18–24, 1895 (NY); Clarke, Pyron, May 7, 1930 (DUKE); Floyd, Biltmore Herb. 4811a (US); Lincoln, Duncan 10327 (GA, NCU); Meriwether, Tracy 8917 (NY); Quitman, Harper 1901 (NY); Randolph, Thorne & Muenscher 7923 (GH); Richmond, Cuthbert 248 (NY); Sumter, Harper, June, 1897 (NY); Union, Leeds 2068 (PH); Whitfield, Harper 244 (NY, US). LOUISIANA: Rapides, Hale, no number or date (NY). MISSISSIPPI: Lowndes, Harbison 4192 (NCU). NORTH CAROLINA: Alamance, Rodgers 365C (NCU); Cabarrus, Rodgers 771C (NCU); Caldwell, Blomquist 13875 (DUKE); Durham, Godfrey 3826 (NCU); Forsyth, Schallert, June 19, 1947 (FLA); Graham, Rodgers 624C (NCU, US); Granville, Rodgers 403C (NCU); Haywood, Blomquist 4425 (DUKE); Henderson, Rodgers 646C (NCU); Mitchell, reported by Gray; Montgomery, Rodgers 462C (NCU); Moore, Fox & Godfrey 1370 (FLA, NCS); Orange, Ashe, May, 1898 (NCU); Polk, reported by Peattie; Randolph, Rodgers 437C (NCU); Rowan, Rodgers 764C (NCS, NCU); Stanly, Rodgers 462C (NCU); Swain, Radford 5260 (NCU); Union, Rodgers 774C (DUKE, NCU). SOUTH CAROLINA: Berkeley, Ravenel, no number or date (GH); Charleston, Godfrey & Tryon 680 (GH, NY, PH, TENN). TENNESSEE: Davidson, Svenson 9592 (GH); Dickson, Svenson 10322 (DUKE, TENN); Lewis, King 69 (DUKE); Wilson, Svenson 9592 (GH).

3. ***Zizia trifoliata*** (Michx.) Fern. (*Z. bebbii* Brit.) Bebb's Zizia.

Plants glabrous, slender, up to 6 dm. tall; leaflets ovate, lanceolate, or elliptic, acute or obtuse at apex, cuneate, truncate, or oblique at base; umbels 1–5;

rays 2–14, slender, often lax; fruit ovoid or broadly ellipsoid, 2–4.5 mm. long. —Native. Flowers in spring and summer.

DISTRIBUTION: Deciduous woods; mts. and pied., sometimes coastal plain. Fla. to Va., Tenn., W. Va., and Ark.; in Southeast (Map X), all states except Ala., Miss., and La.

SPECIMENS CITED: FLORIDA: Alachua, West & Laessle, May 10, 1934 (FLA); Jackson, Explor. Party, March 15, 1937 (FLA); Marion, Miller 536 (US). GEORGIA: Colquitt, Harper 1940 (GH); Meriwether, Tracy 8917 (GH, US); Quitman, Harper 1901 (GH, NY); Rabun, Radford, May 30, 1947 (NCU); Richmond, Cuthbert, May 3, 1901 (FLA); Sumter, Harper 1020 (GH). NORTH CAROLINA: Ashe, Rodgers 808C (NCU, US); Avery, Radford, July 11, 1946 (NCU); Buncombe, Browne, July 2, 1949 (NCU); Burke, Freeman, June 7, 1926 (DUKE); Caldwell, Blomquist 13872 (DUKE); Chatham, Rodgers 81C (NCU); Forsyth, Schallert, May, 1940 (NY); Haywood, Coker et al., July 28, 1926 (NCU); Henderson, reported by Memminger; Iredell, Veerhoff 209 (NCS); Jackson, Rodgers 596C (DUKE, NCS, NCU); Macon, Rodgers 597C (NCU); Madison, Churchill, June 9, 1899 (GH); McDowell, Fox et al. 2170a (NCS); Mitchell, Ashe, June, 1893 (NCU); Orange, Radford 805a (NCU); Polk, Peattie 701 (NCU); Rockingham, DeChalmot, no number or date (US); Rowan, Heller 68 (PH); Rutherford, Rodgers 731C (NCU); Surry, Rodgers 791C (NCU, NY); Swain, reported by Cain; Transylvania, Rodgers 598C (GA, NCS, NCU); Wake, Godfrey, April 27, 1937 (NCS); Watauga, Rodgers 818C (GA, NCU); Yancey, Rodgers 721C (NCU). SOUTH CAROLINA: Greenville, Gibbs, —— (NY); Oconee, House 1973 (US); Pickens, Rodgers 514a (DUKE); Williamsburg, Wiegand & Manning 2308 (GH). TENNESSEE: Carter, Brown 18 (DUKE); Cocke, Kearney 701 (NCU, NY, US); Sevier, Cain & Duncan 427:2 (TENN); Sullivan, Jennison et al. 815 (TENN); Unicoi, Price 989 (DUKE).

20. CARUM L. Caraways.

Glabrous, branching biennials. Taproots fleshy. Leaves pinnately decompound, the segments linear to filiform; sheaths of petioles with hyaline margins. Umbels compound, opposite leaves. Bracts and bractlets absent to few. Flowers white or faintly rose. Calyx-teeth obsolete. Petals spreading, recurved at tips. Stylopodium conic. Ovary and fruit laterally flattened, ribbed. Carpophore split to base. Oil-tubes large, solitary between ribs, 2 on commissure. Seed nearly terete.

1. *Carum carvi* L. Caraway, Carvies.

Plants up to 10 dm. tall; umbels exceeding in length the leaves they oppose; rays and pedicels unequal in flower and fruit, rays 5–14; bracts absent or 1–2, simple or dissected; bractlets absent or few and simple; stamens twice length of petals; styles shorter than petals; fruit (Fig. 20) ellipsoid, oblong-ovoid, or oblong-ellipsoid, 3–4 mm. long; ribs primary, alike; seed sulcate under oil-tubes.—Introduced. Fruits used medicinally and for flavoring.

Caraway is occasionally grown in gardens and might be expected to escape from cultivation.

DISTRIBUTION: Waste-places. N. C. to E. Can., west to Wash. and B. C.; in Southeast, only collection seen from Junaluska Mt., N. C.

SPECIMEN CITED: NORTH CAROLINA: Haywood, Blomquist 4370 (DUKE).

21. LIGUSTICUM L.

Mostly glabrous, erect perennials. Roots large, bearing a crown of fibers. Leaves decompound, petiolate. Umbels compound. Bracts absent or inconspicuous; bractlets absent or few and narrow. Flowers regular. Calyx-teeth obsolete to distinct. Petals white or pinkish, recurved at tips. Styles short. Ovary and fruit longer than wide, laterally flattened; fruit ribbed. Carpophore split to base. Oil-tubes numerous between ribs and on commissure. Seeds dorsally flattened.

1. *Ligusticum canadense* (L.) Brit. Lovage, Angelico, Sea Parsley.

Plants tall, up to 20 dm., glabrous, coarse; roots with odor of celery; stems very brittle; leaves 1–4-ternate or ternate-pinnate, very large at base, reduced to simple bract-like structures on inflorescence branches; blades ovate, elliptic, or lanceolate, coarsely serrate, acute at apex, cuneate or oblique at base; umbels cymosely displayed on naked-appearing branches, these branches opposite or whorled; rays 4–14; petals white; stamens more than twice length of petals; fruits (Fig. 21) ellipsoid to ovoid, about 5 mm. long; ribs primary, thin, alike.—Native. Flowers in spring and summer.

DISTRIBUTION: Rich woods and embankments; mts. and pied., rarely coastal plain. Ga. to Ark., north to Penn. and Mo.; in Southeast (Map II), Ala., Ga., S. C., N. C., and Tenn.

SPECIMENS CITED: ALABAMA: Cullman, Mohr, June 23, 1895 (US); De Kalb, Harper 3999 (US); Etowah, Pollard & Maxon 348 (US); Lee, Earle & Baker 1162 (NY). FLORIDA: None. GEORGIA: Clarke, Harper 41 (GH, NY); Dade, Eyles 5 (GH); De Kalb, Small, Aug. 1–6, 1895 (NY); Gwennett, Small, July 11, 1893 (NY, US); Jasper, Porter, 1846 (PH); Madison, Harper 1528 (PH); Pickens, Leeds 2125 (DUKE, PH); Rabun, Radford, Aug. 24, 1946 (NCU); Richmond, Cuthbert, July, 1900 (FLA); Stephens, Duncan 10030 (GA, NCU); Sumter, Harper 1019 (GH, NY, US); Walker, Ruth 425 (US). LOUISIANA & MISSISSIPPI: None. NORTH CAROLINA: Alleghany, Rodgers 801C (NCS, NCU); Ashe, Rodgers 807C (NCU); Avery, Rodgers 823C (NCU); Buncombe, Rodgers 709C (NCU); Burke, Rodgers 722C (NCU); Caldwell, Small & Heller, July 31, 1891 (NY); Chatham, Rodgers 434C (NCU); Cherokee, Rodgers 618C (NCU); Durham, Blomquist 943 (DUKE); Forsyth, Rodgers 784C (NCU); Gaston, Rodgers 744C (NCU); Graham, Rodgers 625C (NCU); Haywood, Rodgers 699C (NCU); Henderson, reported by Memminger; Iredell, Hyams, July, 1880 (NY); Jackson, Rodgers 595C (NCU); Johnston, Fox & Godfrey 1681 (DUKE, FLA, NCS); Macon, Rodgers 590C (NCU); Madison, Rodgers 689C (NCU); McDowell, Rodgers 718C (NCU); Mitchell, Chickering, July 1, 1880 (US); Montgomery, Rodgers 582C (NCU); Orange,

Rodgers 207C (NCU); Polk, Peattie 1356A (NCU); Rowan, Heller 66 (PH); Rutherford, Rodgers 730C (NCU); Stanly, Rodgers 453C (NCU); Stokes, Sample 17 (DUKE); Surry, Williams 255 (DUKE); Swain, Beardslee 12 (US); Transylvania, Rodgers 601C (NCU); Wake, Rodgers 429C (NCU); Warren, Rodgers 410C (NCU); Watauga, Rodgers 817C (NCU); Yancey, Rodgers 824C (NCU). SOUTH CAROLINA: Anderson, F. H. E., 1886 (NY); Greenville, Peattie 1263A (NCU); Lancaster, Huntley 286 (DUKE); Pickens, Rodgers 347 (DUKE). TENNESSEE: Carroll, Sharp et al. 13094 (TENN); Carter, Britton, Sept. 11, 1895 (NY); Cocke, Kearney 704 (NCU, NY); Hamilton, Bicknell, June, 1894 (NY); Knox, student 2718 (TENN); Morgan, Rice & Underwood 1336 (TENN); Rhea, Shanks et al. 4373 (TENN); Sevier, Sharp & M. B. W. 1253 (TENN); Van Buren, Shanks & Clebsch 4530 (TENN).

22. AEGOPODIUM L. Goutweeds.

Coarse, glabrous, branching perennials. Fibrous roots from rhizomes. Leaves biternate or ternate, blades broad, toothed or sometimes cut. Sheaths of petioles with hyaline margins. Umbels compound, opposite the leaves or cymose. Bracts and bractlets usually absent. Flowers regular. Calyx-teeth small or absent. Petals white, spreading, recurved at tips. Stylopodium conic. Ovary laterally flattened, longer than wide. Fruit laterally flattened, longer than wide, ribbed. Oil-tubes absent. Seed subterete.

1. *Aegopodium podagraria* var. *variegatum* Bailey. Goutweed, Goutwort, Herb-Gerard, Wild or English Masterwort, Bishop's-weed, Dwarf Elder, Bishop's-Elder, White-ash-herb.

Plants up to 11 dm. tall; leaves variegated, biternate below to ternate above; blades ovate, elliptic, or lanceolate, acute to acuminate, serrate and sometimes cut; rays of umbel 9–25; stamens more than twice length of petals; styles shorter than petals; fruit ovoid to oblong-ovoid, 3–4 mm. long; ribs filiform, equal.—Introduced ornamental. Flowers in summer.

DISTRIBUTION: Waste-places, especially around homesites in E. Amer. from N. C. to Que.

SPECIMEN CITED: NORTH CAROLINA: Forsyth, Siewers, May 12, 1911 (DUKE).

23. SPERMOLEPIS Raf.

Glabrous, slender, branching annuals. Taproots. Leaves finely dissected. Umbels compound with few rays and flowers. Bracts absent or solitary and simple; bractlets few and narrow. Flowers regular. Calyx-teeth obsolete. Petals white, not recurved at tips. Stamens and styles shorter than petals. Ovary and fruit laterally flattened, usually with tubercles or bristles. Carpophore split at tip. Oil-tubes usually solitary between ribs, 2 on commissure. Seed nearly terete, face sulcate.

1. *Spermolepis divaricata* (Walt.) Brit. Rough-fruited Spermolepis.

Plant up to 7 dm. tall, delicate, much-branched; sheaths of leaves with hyaline margins; umbels asymmetrical, borne on rather symmetrically forked branches; rays 3–7, slender, equal or unequal, the center one sometimes very short and bearing a reduced umbelet; pedicels 1–6, unequal, very slender; flowers small, center ones often sessile or on short pedicels; ovary tuberculate; fruit (Fig. 22) tuberculate, ellipsoid, ovoid, or orbicular, 1.5–2 mm. long; ribs primary, alike. —Native. Flowers in spring. This plant is sometimes confused with *Apium leptophyllum*.

DISTRIBUTION: Open waste-places, especially sandy soil; coastal plain. Fla. to Tex., north to Va. (N. J. on ballast) and Kans. (Small gives N. M.); in Southeast (Map VIII), all states (reported in Tenn.).

SPECIMENS CITED: ALABAMA: Baldwin, Schallert 526 (DUKE); Clay, Harper 3733 (GH, NY, PH, US); Crenshaw, Earle 2035 (US); Mobile, Mohr, May, 1877 (GH, NY, US). FLORIDA: Alachua, Meredith, March 14, 1899 (PH); Baker, West & Arnold, April 25, 1940 (FLA); Bay, Banker 3676 (NY); Bradford, West & Arnold, May 15, 1940 (FLA); Brevard, Rhoads, March 23, 1928 (FLA); Columbia, Jaspersen, March 29, 1893 (FLA); Dade, Biltmore Herb. 1351c (NY, US); Duval, Curtiss 4609 (GH); Escambia, Baker 1624 (NY, US); Gadsden, Rugel, May, 1843 (NY); Gilchrist, Martin et al., May 19, 1940 (FLA); Hamilton, West & Arnold, April 11, 1940 (FLA); Hillsborough, Smith, March 10, 1880 (GH, US); Lake, Nash, April 1–15, 1894 (GH, NY, PH); Leon, Kurz, May, 1943 (FLA); Levy, Garber, April, 1876 (PH, US); Marion, Rhoads, April 16, 1937 (FLA); Osceola, Singeltary 220 (DUKE, NCS); Pasco, Barnhart 2555 (NY); Pinellas, Moldenke 1057 (DUKE, NY); Polk, Schallert 1332 (FLA); Putnam, Barnhart 2056 (NY, US); Seminole, Torrey, March, 1872 (NY); St. Johns, Curtiss 6133 (FLA, NCU); Sumter, West & Arnold, April 4, 1946 (FLA); Suwanee, Explor. Party, March 17, 1939 (FLA); Volusia, Oosting 209 (DUKE). GEORGIA: Burke, Harper 773 (NY, US); Chatham, Small 8490 (GH, NY, US); Houston, Ainsworth, May 7, 1944 (PH); Jenkins, Harper 787 (GH, NY, US); Richmond, Porter, April, 1847 (PH); Screven, Cronquist 4995 (GH, US). LOUISIANA: County unknown, Torrey, 1839 (GH). MISSISSIPPI: Harrison, Tracy, May 3, 1898 (GH); Jackson, Skehan S126 (DUKE). NORTH CAROLINA: Bladen, Rodgers 266C (NCU); Brunswick, Rodgers 313C (NCU); Carteret, Ashe, April 11, 1898 (NCU); Columbus, Rodgers 273C (GA, NCU, NY); Craven, reported by Croom; Cumberland, collector and date unknown (GH, NY); Dare, Ashe, April 11–25, 1898 (NCU); Harnett, Rodgers 261C (DUKE, NCU); Johnston, Rodgers 184C (NCU); Moore, Radford & Stewart 318 (NCU); New Hanover, Rodgers 302C (NCU); Richmond, Williamson, 1895 (PH); Robeson, Rodgers 337C (NCU, US); Samson, Correll 386 (DUKE); Wake, Buell 1967 (DUKE, NCS); Wayne, Totten, May 14, 1926 (NCU). SOUTH CAROLINA: Aiken, Biltmore Herb. 1351b (US); Beaufort, Churchill, May 2, 1917 (GH); Charleston, Robinson 162 (GH); Chesterfield, Williamson, April, 1895 (PH); Clarendon, Stone 94 (PH); Darlington, Smith, May 12, 1932 (NCU); Dorchester, Hunt 821A (CLEMS);

Florence, Bartram 2267 (PH); Georgetown, Radford & Stewart 986 (NCU); Horry, Powell, June 23, 1931 (FUR); Orangeburg, House 3288 (NY); Richland, Bartram, May 16, 1912 (PH). TENNESSEE: Davidson, reported by Gattinger.

24. APIUM L.

Glabrous, branching annuals, biennials, or perennials. Taproots or rhizome with fibrous roots. Leaves pinnately or ternately compound to decompound. Umbels compound or simple, sessile or pedunculate, opposite leaves. Bracts and bractlets present or absent. Flowers nearly regular. Calyx-teeth small or obsolete. Petals white, spreading, recurved or straight at tips; stylopodium conic. Ovary and fruit laterally flattened, ribbed. Carpophore entire or split nearly to base. Oil-tubes solitary between ribs, 2 on commissure. Seed subterete.

Delicate, weak-stemmed annuals with filiform or linear leaflets; umbels simple or compound (1–3 rays); petals not recurved at tips . . . . 1. *A. leptophyllum*
Robust, strong-stemmed biennials with broad leaflets; umbels compound (6–16 rays); petals recurved at tips . . . . 2. *A. graveolens*

1. *Apium leptophyllum* (Pers.) F. Muell. (*Cyclospermum ammi* [L.] Brit.) Marsh Parsley.

Plants with green, slender stems, erect or creeping, up to 7 dm. long; blades of leaves with only one vein; umbels numerous along most of stem length, simple umbels usually 1–3 from a node, compound umbels, if present, sessile or pedunculate; flowers small, 1–18 to umbelet, central flower sometimes sessile or subsessile; calyx-teeth absent; stamens and styles shorter than petals; stylopodium low; ribs primary, equal; carpophore split at apex; seed subterete.—Native. Flowers in spring and summer. This plant is sometimes confused with *Spermolepis divaricata*.

DISTRIBUTION: Waste-places, often in very sandy soil; coastal plain. Fla. to N. C., west to Tex., Ariz., N. M., and Calif. (on ballast grounds on Long Island, N. Y., and in Ore.); Mex., C. A., W. I., and S. A.; in Southeast (Map VIII), all states (reported to be common on coast of Miss.).

SPECIMENS CITED: ALABAMA: Mobile, Mohr, 1897 (US); Sumter, Harper 3594 (GH, NY, PH, US). FLORIDA: Alachua, Murrill, May 6, 1940 (DUKE); Baker, West & Arnold, April 25, 1940 (FLA); Columbia, Morris, June 18, 1903 (US); Dade, Small 6816 (DUKE, FLA, GH, NCU, NY, TENN); Duval, Curtiss, March 28, 1894 (NCS, NY, PH, US); Franklin, Chapman, 1875 (US); Gadsden, Curtiss 6165 (FLA); Jefferson, Lighthipe, March, 1890 (NY); Leon, Moldenke 5982 (NY); Putnam, Barnhart 2122 (NY); Volusia, Small 8678 (FLA, GH, NY, US); Walton, Hume, May 9, 1938 (FLA). GEORGIA: Chatham, Kolthoff, April 9, 1927 (US); Clarke, Dunnaway, May 23, 1929 (TENN); Glynn, McAtee 3265 (US). LOUISIANA: Jefferson, Ball 310 (GH, US); Natchitoches, Palmer 7382 (NY); Orleans, Pond, Feb. 21, 1888 (US); Plaquemines, Tracy & Lloyd 136 (GH, US); Rapides, Ball 384 (GH, US); Terrebonne, Innes & Warnock 713 (GH). MISSISSIPPI: Along coast,

reported by Lowe. NORTH CAROLINA: Brunswick, Rodgers 321C (NC, NY); Johnston, Rodgers 341C (DUKE, NCU); Richmond, Williamson, May, 1895 (PH); Robeson, Rodgers 338C (GA, NCU). SOUTH CAROLINA: Beaufort, Churchill, May 1, 1917 (GH); Charleston, Robinson 164 (GH); Dorchester, Correll 5334 (NCS); Georgetown, Godfrey & Tryon 282 (DUKE, GH, TENN); McCormick, Duncan 9467 (GH); Richland, Taylor, no number or date (GH, NY, US). TENNESSEE: Wilson, Svenson 7158 (GH, TENN).

2. *Apium graveolens* L. (*Celeri graveolens* Brit.) Celery, Smallage.

Plants aromatic, up to 15 dm. tall; stems ridged and grooved; basal leaves pinnate-ternate or bipinnate, blades cuneate at base, toothed and variously cut; cauline leaves trifoliate or 3-lobed; umbels numerous, sessile or short-pedunculate; calyx-teeth obscure or small; stamens slightly longer than petals, styles short; fruits (Fig. 23) subellipsoid, about 1.5 mm. long; ribs primary, filiform; carpophore split at apex; seed nearly terete (Fig. 23).—Introduced as food plant. Fruits used medicinally and for flavoring. Flowers in spring and summer.

DISTRIBUTION: Waste-places throughout U. S.; in Southeast (Map VIII), rare.

SPECIMENS CITED: NORTH CAROLINA: Brunswick, Rodgers 322C (NCU). SOUTH CAROLINA: Charleston, Hunt 1547 (CLEMS); Darlington, Norton, April 20, 1921 (US). TENNESSEE: Reported by Gattinger.

25. AMMI L. Bishop's-weeds.

Glabrous, branching annuals, biennials, or perennials. Taproots. Leaves decompound, the ultimate divisions filiform, linear, or lanceolate. Umbels compound. Bracts and bractlets numerous. Calyx-teeth obsolete. Petals white, recurved at tips. Stylopodium low-conic. Ovary laterally flattened. Fruit laterally flattened, ribbed. Carpophore entire or split to base. Oil-tubes solitary between ribs, 2 on commissure. Seed nearly terete.

1. *Ammi visnaga* (L.) Lam.

Plants up to 12 dm. tall; rays of umbel numerous, arising from a disk; pedicels arising from disks; flowers irregular; fruit (Fig. 24) ovoid to oblong-ovoid, 2–2.5 mm. long; ribs equal.—Introduced.

Gerald McCarthy collected this plant on ballast at Wilmington in 1892 (identified as *Discopleura costata*). It probably did not become established since no other collections are known from there, and recent collecting in the same area failed to disclose it. Williamson's collection marked *Ammi visnaga* (Sept., 1900; NY) is *Ptilimnium costatum*.

DISTRIBUTION: Waste-places around seaports. N. C., Fla., and Ala. (reported).

SPECIMENS CITED: ALABAMA: Mobile, reported by Mohr. FLORIDA: County not given, Curtiss 6860 (GH). NORTH CAROLINA: New Hanover, McCarthy, June, 1892 (US).

26. SIUM L.

Glabrous, caulescent, branching perennials. Roots fibrous. Leaves usually pinnate or pinnately decompound, sometimes much dissected. Umbels compound, opposite leaves. Bracts simple, entire or variously cut; bractlets simple, entire. Flowers mostly regular. Calyx-teeth obsolete or prominent. Petals white, spreading, recurved at tips. Stylopodium depressed. Ovary and fruit laterally flattened, ribbed. Carpophore filiform, usually split to base, sometimes not separating from mericarps. Oil-tubes variable, 1–3 between ribs and 2–several on commissure. Seed subterete.

1. *Sium suave* Walt. (*S. cicutaefolium* Schrank) Water Parsley, Water Parsnip, Hemlock.

Plants up to 2 mm. tall; adventitious roots sometimes arising from lower nodes; stem sharply angular; leaves may be dimorphic, most leaves pinnate, the lower leaves (sometimes submerged) may be pinnately dissected; blades lanceolate or linear, acute, regularly serrate; rachis of leaf septate, hollow; rays 6–20, longest about 3.5 cm.; calyx-teeth linear to ovate; fruit (Fig. 25) ellipsoid to oblong, 2–3 mm. long; ribs primary, alike.—Native. Flowers in summer and fall.

DISTRIBUTION: Very wet places along streams and in fresh or salt water marshes; coastal plain, sometimes pied. Fla., Nev., and Calif., north to Newf. and B. C.; in Southeast (Map XII), Ala., Fla., La. (?), N. C., S. C., and Tenn.

SPECIMENS CITED: ALABAMA: Mobile, Mohr, no number or date (US). FLORIDA: County and date not given, Chapman (PH). GEORGIA: None. LOUISIANA: County and date not given, Hale, ? after state. MISSISSIPPI: None. NORTH CAROLINA: Brunswick, Wells, Aug. 27, 1947 (NCS); Carteret, Rogers 34166 (DUKE); Chowan, Rodgers 557C (NCU); Craven, Rodgers 849C (NCU); Dare, Radford & Stewart 865 (NCU); Durham, Hueske, May 3, 1947 (NCU); Henderson, Rodgers 680C (NCU); Johnston, Rodgers 182C (NCU); Martin, Alexander, July 28, 1923 (NCU); New Hanover, Rodgers 867C (GA, NCU, NY, US); Onslow, Godfrey 6395 (GH, US); Perquimans, Rodgers 550C (DUKE, GA, NCS, NCU, NY, US). SOUTH CAROLINA: Berkeley, Godfrey & Tryon 487 (DUKE, GH, NY, US); Clarendon, Stone 515 (PH); Georgetown, Godfrey & Tryon 1056 (DUKE, GH, NY, TENN, US). TENNESSEE: Lake, Shanks 3171 (TENN).

27. CICUTA L. Water Hemlocks.

Tall, glabrous, branching perennials. Roots fleshy. Leaves decompound, blades broad, veins ending near notches between the teeth. Umbels large, compound, opposite the leaves or cymose. Bracts absent or few; bractlets simple. Flowers regular, perfect and staminate. Calyx-teeth distinct. Petals white, spreading,

recurved at tips. Stamens longer than petals. Styles shorter than petals. Stylopodium broad. Ovary and fruit laterally flattened; fruit ribbed. Carpophore split to base; oil-tubes solitary between ribs, 2 on commissure. Seed nearly terete, face concave to plane, often sulcate under oil-tubes.

Fruit not constricted at commissure; lateral ribs larger than others; ribs broader or narrower than intervals between them; leaflets tending to be thin and to have angular teeth ..... 1. *C. maculata*

Fruit constricted at commissure; ribs appearing about equal, broader than intervals between them; leaflets tending to be thicker, to have more reticulate venation, and to have rounded teeth ..... 2. *C. mexicana*

1. *Cicuta maculata* L. Water Hemlock, Poison Parsnip, Musquash Root, Cowbane, Beaver-poison.

Plants up to 18 dm. tall; leaves ternately or pinnately decompound; leaflets lanceolate, ovate, or elliptic, coarsely serrate, acuminate to acute at apex, tapering or oblique at base; rays 12–26; calyx-teeth acute; fruit (Fig. 26) ovoid or ellipsoid, 2–4 mm. long; lateral ribs together forming a broad band at commissure (wedge-shaped in cross section); seed sulcate under oil-tubes.—Native. Plant poisonous, especially roots; dangerous to cattle. Flowers in late spring to fall.

C. maculata is distinct in the heart of its range, but is not always distinct where it overlaps with the range of *C. mexicana*. *C. mexicana* seems to be most distinct in Florida where the combination of fruit and leaf characters is fairly constant. In N. C., plants are sometimes found having the typical fruits of *C. mexicana* and vegetative characters of *C. maculata*.

It is possible that the status of these two entities will be changed when they are better known. Whether there is hydridization or whether *C. mexicana* is really an extreme expression of a variable *C. maculata* is not known. Part of the confusion might be solved by knowing the plants better in the field. There is little herbarium material with mature fruits and even less with representative leaves. The plants are so large that they do not lend themselves very well to good representative preservation. Most collectors simply cut off the inflorescence to which is attached a few reduced upper leaves.

DISTRIBUTION: Swamps and near streams; mts., pied., and coastal plain. Fla. to Tex., north to E. Can., N. D., and Alas. (reported by Anderson, 1942); in Southeast (Map XII), all states except Ala. (probably present) and Miss. (reported).

SPECIMENS CITED: FLORIDA: Alachua, O'Neill, Jan., 1925 (FLA); Clay, West & Arnold, July 15, 1947 (FLA); Lake, Hitchcock, 1894 (FLA). GEORGIA: Gordon, Leeds 2185 (PH); Gwinnett, Small, July 20, 1893 (NY); Madison, Duncan 9854 (GA, NCU); Richmond, Cuthbert, July 10, 1901 (FLA). LOUISIANA: Natchitoches, Palmer (US); Rapides, Hale, no number or date (PH). MISSISSIPPI: Reported by Brown & Lowe. NORTH CAROLINA: Alamance, Rodgers 367C (NCU); Beaufort, Rodgers 355C (NCU); Bladen, Fox & Whitford 1848 (NCS);

Buncombe, Oosting 34464 (DUKE, PH); Caldwell, Rodgers 839C (NCU); Camden, Rodgers 538C (NCU); Carteret, Rogers 3416a (DUKE); Caswell, Rodgers 386C (NCU); Chatham, Rodgers 435C (NCU); Cherokee, Rodgers, 619C (NCU); Chowan, Godfrey 5381 (GH, US); Clay, Rodgers 615C (NCU); Currituck, Rodgers 531C (NCU); Dare, Rodgers 525C (NCU); Durham, Rodgers 482C (NCU); Forsyth, Schallert 9442 (DUKE); Gates, Correll 2244 (DUKE); Granville, Rodgers 424C (NCU); Guilford, Rodgers 374C (NCU); Harnett, Rodgers 477C (NCU); Haywood, Rodgers 698AC (NCU); Henderson, Rodgers 670C (NCU); Hertford, Rodgers 561C (NCU); Macon, Rodgers 605C (NCU); Madison, Rodgers 693C (NCU); McDowell, Rodgers 713C (NCU); Mecklenburg, Correll 3029 (DUKE); Moore, Rodgers 464C (NCU); Orange, Rodgers 393C (NCU); Pamlico, Rodgers 349C (NCU); Pasquotank, Rodgers 542C (NCU); Person, Rodgers 399C (NCU); Polk, Peattie 1299B (NCU); Randolph, Rodgers 443C (NCU); Rockingham, Rodgers 382C (NCU); Stanly, Rodgers 454C (NCU); Stokes, Rodgers 381C (NCU); Swain, Rodgers 702C (NCU); Transylvania, Rodgers 633AC (NCU); Tyrrell, Rodgers 514C (NCU); Union, Correll 934 (DUKE); Wake, Rodgers 427AC (NCU); Washington, Rodgers 507C (NCU); Watauga, Stewart 1574 (NCU); Wilson, Rodgers 358C (NCU); Yancey, Rodgers 830C (NCU). SOUTH CAROLINA: Aiken, Radford 550 (NCU). TENNESSEE: Bledsoe, Sharp 1646 (TENN); Blount, Greene 4097 (TENN); Carroll, Svenson 517 (GH); Coffee, Svenson 9061 (GH, PH); Knox, Ruth 212 (GH); Lewis, King 180 (NY); Obion, Eyles 215 (TENN); Sevier, Sharp 362 (TENN); Unicoi, Price 978 (DUKE); Union, Kalter, June 19, 1936 (TENN).

2. *Cicuta mexicana* C. & R. (*C. curtissii* C. & R.; *C. maculata* var. *curtissii* [C. & R.] Fern.)

Plants coarse, up to 24 dm. tall; leaves ternately or pinnately decompound; leaflets thickish, coarsely serrate, the teeth tending to be rounded; veins tending to be much reticulate; fruit subglobose, 2–3 mm. broad and tall; seed sulcate under oil-tubes.—Native. Plant poisonous, especially roots; dangerous to cattle. Flowers from late spring to fall.

DISTRIBUTION: Swamps and near streams; chiefly coastal plain. Fla. to N. J., southwest to Tex. and Mex.; in Southeast (Map XII), all states except Tenn.

SPECIMENS CITED: ALABAMA: Lee, Earle & Baker (NY); Talladega, Pollard & Maxon 218 (GH, NY, US). FLORIDA: Alachua, West, May 18, 1937 (FLA); Brevard, Fredholm 5860 (GH, NY, US); Broward, Small 4121 (DUKE, FLA, GH, TENN, US); Citrus, Murrill, June 6, 1941 (FLA); Clay, Murrill 263 (US); Dade, Fisher 47 (US); Duval, Curtiss 6845 (GH, NY, US); Glades, Moldenke 1026 (DUKE, NY); Hillsborough, Britton & Wilson 85 (NY); Lake, Nash 1025 (GH, NY); Manatee, Cuthbert, 1926 (FLA); Orange, Davis, Aug., 1935 (FLA); Palm Beach, Small 412 (NY); Putnam, Laessle, July 23, 1940 (FLA); St. Johns, Browne A-34 (NCU); Seminole, Baker & Arnold, July 30, 1940 (FLA); Volusia, Ames, Feb. 6, 1944 (GH). GEORGIA: Clarke, Pyron, July 9, 1929 (DUKE, GH); Madison, Wiegand &

Manning 2253 (GH); Quitman, Harper 1899 (GH, US). LOUISIANA: Rapides, Correll 9992 (DUKE); St. Tammany, Drummond, 1832 (US); Terrebonne, Wurzlow, Sept. 4, 1913 (NY). MISSISSIPPI: Reported by Lowe. NORTH CAROLINA: Avery, Kelsey 94 (US); Brunswick, Rodgers 891AC (NCU); Carteret, Rodgers 855C (NCU); Caldwell, reported by Rydberg; Columbus, Rodgers 883C (NCU); Craven, Rodgers 859C (NCU); Currituck, Godfrey 5293 (GH); Henderson, Rodgers 705C (NCU); New Hanover, Rodgers 868C (NCU); Onslow, Rodgers 875C (NCU); Richmond, Rodgers 590C (NCU). SOUTH CAROLINA: Berkeley, Hunt 1285a (CLEMS); Charleston, Alexander, July 29, 1915 (US). TENNESSEE: None.

28. PTILIMNIUM Raf. Mock Bishop's-weeds.

Glabrous, erect, branching annuals. Roots fibrous. Leaves decompound, the ultimate divisions filiform or linear. Umbels compound, opposite leaves. Bracts simple to pinnate; bractlets simple. Flowers regular. Calyx-teeth distinct. Petals white, spreading, recurved at tips. Stylopodium conic. Ovary laterally flattened. Fruit somewhat laterally flattened, ribbed; ribs equal. Carpophore split at tip to near the base. Oil-tubes solitary between the ribs, 2 on commissure. Seed subterete to dorsally flattened.

Leaves with divisions loosely arranged; styles in flower or fruit about equal or shorter than stylopodium; stamens slightly longer than petals . . . . 1. *P. capillaceum*

Leaves with divisions so densely arranged that they appear bushy; styles in flower or fruit more than twice as long as stylopodium; stamens at least twice length of petals 2. *P. costatum*

1. *Ptilimnium capillaceum* (Michx.) Raf. Mock Bishop's-weed, Herb-William, Bullwort.

Plants up to 9 dm. tall; umbels usually many; rays 2–20, longest 2.5 cm. long or less, rarely 3.5 cm.; bracts pinnate and tripartite, rarely single or forked; styles shorter than petals; ovary ribbed; fruit (Fig. 27) ovoid, 2–3 mm. long; band of cork between lateral ribs; carpophore split almost to base, appearing split only at apex where the halves diverge.—Native. Flowers in spring and summer.

Previously the corky band at the commissure was described as a part of the lateral ribs. The position taken here is that the ribs and corky bands are distinct and not a single structure. That is borne out by looking at sections of green fruits which show the mass of cork distinctly separated from the ribs.

DISTRIBUTION: Usually in open bottom land, low pastures, and road ditches; pied. and coastal plain. Fla. to Tex., north to Mass. and Kans.; in Southeast (Map XI), all states.

SPECIMENS CITED: ALABAMA: Lee, Pollard & Maxon 57 (NY, US); Mobile, Mackensie 4011 (NY); Walker, Smith, Aug., 1877 (US). FLORIDA: Common; specimens from 33 counties examined (records omitted to save space). GEORGIA: Chatham, Eyles 4354 (DUKE); Clarke, Pyron, July 4, —— (DUKE); Cobb,

Biltmore Herb. 216d (US); Columbia, Duncan 9730 (FLA); De Kalb, Pennell 4055 (NY); Dougherty, Thorne 4996 (US); Jasper, collector unknown, 1846 (PH); Madison, Duncan 9852 (GA, NCU); Richmond, Radford 599 (NCU); Thomas, Small, May 28–June 6, 1885 (NY). LOUISIANA: Calcasieu, Mackenzie 519 (NCU); Jeff Davis, Palmer 7645 (NY); Lafayette, Correll 9427 (DUKE); Livingston, Correll 9157 (DUKE); Orleans, Waite, June 2, 1885 (US); Plaquemines, Langlois, June, 1886 (NY); Rapides, Ball 597 (GH, NY, US); St. Tammany, Anect 58 (US). MISSISSIPPI: Forrest, collector unknown, June 9, 1941 (NY); Harrison, Baker, April 27, 1898 (US); Jackson, Tracy 6391 (NY, US); Madison, McDougall 1382 (US). NORTH CAROLINA: Beaufort, Rodgers 495C (NCU); Bertie, Rodgers 559C (NCU); Bladen, Biltmore Herb. 988a (US); Brunswick, Godfrey 49812 (NCS); Cabarrus, Rodgers 767C (NCU); Camden, Rodgers 539C (NCU); Carteret, Godfrey 49807 (NCS); Caswell, Rodgers 387C (NCU); Catawba, Correll 2809 (DUKE); Chatham, Rodgers 436C (NCU); Chowan, Kearney 1911 (US); Columbus, Rodgers 884C (NCU); Craven, Blomquist 11235 (DUKE); Cumberland, Biltmore Herbarium 2161 (US); Currituck, Rodgers 532C (NCU); Dare, Rodgers 526C (NCU); Durham, Rodgers 481C (NCU); Edgecombe, Rodgers 487C (NCU); Franklin, Rodgers 421C (NCU); Gaston, Rodgers 741C (NCU); Gates, Rodgers 546C (NCU); Greene, Correll 1340 (DUKE); Harnett, Rodgers 474C (NCU); Hyde, Rodgers 520C (NCU); Johnston, Rodgers 473C (NCU); Jones, Rodgers 346C (NCU); Lincoln, Correll 2904 (DUKE); Martin, Rodgers 497C (NCU); Moore, Rodgers 467C (NCU); Montgomery, Rodgers 456C (NCU); Nash, Sample 14 (DUKE); New Hanover, Wells & Shunk, May 14, 1937 (NCS); Northampton, Rodgers 566C (NCU); Onslow, Rodgers 864C (NCU); Pasquotank, Rodgers 541C (NCU); Pender, Rodgers 872C (NCU); Perquimans, Rodgers 549C (NCU); Pitt, Rodgers 494C (NCU); Richmond, Wiegand & Manning 2286 (GH); Robeson, Rodgers 342C (NCU); Rowan, Rodgers 447C (NCU); Scotland, Rodgers 575C (NCU); Stanly, Rodgers 455C (NCU); Tyrrell, Rodgers 511C (NCU); Union, Correll 937 (DUKE); Wake, Rodgers 461C (NCU); Washington, Rodgers 503C (NCU); Wilson, Sample 13 (DUKE). SOUTH CAROLINA: Aiken, Ravenel, July, 1869 (US); Anderson, Davis 1907 (US); Charleston, Hunt 4745 (CLEMS); Darlington, Smith 846 (NCU); Georgetown, Godfrey & Tryon 69 (DUKE, GH, NY); Greenwood, Biltmore Herb. 2161C (US); Greenville, collector unknown, June 16, 1937 (FUR); Horry, Coker, July 29, 1945 (NCU); Lexington, McGregor 520 (US); Spartanburg, Walker 3501 (DUKE, NCU). TENNESSEE: Chester, Sharp et al. 12780 (TENN); Giles, Svenson 8817 (GH); Hardeman, Sharp et al. 12588 (TENN); Madison, Sharp et al. 12536 (TENN); McNairy, Bain 412 (GH, NY).

2. *Ptilimnium costatum* (Ell.) Raf.

Plants up to 16 dm. tall; rays about 20–22, longest up to 5 cm. long; bracts simple and pinnate; styles long and spreading; fruit ovoid, 3–4.5 mm. long; band of cork between lateral ribs.—Native. A new interpretation is placed upon the nature of the corky commissural band (see description under *P. capillaceum*).

DISTRIBUTION: Swampy places; chiefly coastal plain. Ga. to Tex., north

to N. C. (known only from mouth of Cape Fear River) to Mo., in Southeast (Map XI), Ala., Ga., La., and N. C.

SPECIMENS CITED: ALABAMA: Etowah, Vasey, 1878 (NY). GEORGIA: Screven, collector and date unknown (GH); Walker, Harper 347 (US). LOUISIANA: West La., Hale, no number or date (NY); Winn, Correll 10042 (DUKE). NORTH CAROLINA: Brunswick, Bartram, Oct. 3, 1908 (GH); New Hanover, Radford 660 (NCU).

29. LILAEOPSIS Greene

Glabrous, creeping perennials. Roots fibrous at the nodes. Leaves clustered, reduced to hollow, septate phyllodes. Umbels small and simple, on peduncles shorter or longer than leaves. Bracts few and simple. Flowers regular. Calyx-teeth small or obsolete. Petals white, concave, not reflexed (?). Stamens and styles shorter than petals. Ovary and fruit laterally flattened or almost globose, ribbed. Carpophore absent. Oil-tubes solitary between ribs, 2 on commissure. Seed subterete.

Inflorescence longer than leaves; leaves usually less than 6 cm. long 1. *L. chinensis*
Inflorescence shorter than leaves; leaves usually over 6 cm. long 2. *L. carolinensis*

1. *Lilaeopsis chinensis* (L.) Kuntze (*L. lineata* [Michx.] Greene) Joint-leaf, Lilaeopsis.

Leaves spatulate, usually 1–2 at a node; peduncles 2–8 cm. long; umbels with 4–10 flowers or fruits; stylopodium conic; fruit (Fig. 28) subglobose, wide band of cork at the commissure.—Native. Flowers in summer.

The name implies an association with China which is not the case. It probably resulted from a misunderstanding of location. See description under *Ptilimnium capillaceum* for a new interpretation of the corky band at the commissure.

DISTRIBUTION: Mud of brackish or salt marshes and river banks; coastal plain. La. to Fla., north to N. S.; in Southeast (Map XI), Fla., Ga., La., N. C., and S. C.

SPECIMENS CITED: ALABAMA: None. FLORIDA: Duval, Curtiss 993 (FLA, GH, NY, US); Hillsborough, Garber, May, 1896 (US); Levy, West & Arnold, April 12, 1946 (FLA). GEORGIA: Liberty, Harper 2182 (NY, US). LOUISIANA: County not given, Braun 6202 (GH). MISSISSIPPI: None. NORTH CAROLINA: Brunswick, Radford 5198 (NCU); Carteret, Blomquist et al., July 15, 1938 (DUKE); New Hanover, Oosting 2078 (DUKE); Tyrrell, Radford & Rodgers 516C (DUKE, GA, NCS, NCU, NY, US). SOUTH CAROLINA: Charleston, Hunt, no number or date (CLEMS).

2. *Lilaeopsis carolinensis* C. & R. (*L. attenuata* [H. & A.] Fern.) Carolina Joint-leaf, Carolina Lilaeopsis.

Leaves oblong or spatulate, peduncles up to 5 cm. long; umbels with 4–15 flowers or fruits; stylopodium low; fruit ovoid, wide band of cork at commissure.—Native.

DISTRIBUTION: Wet places; coastal plain. Known from Ark., La., N. C., S. C., Va., and S. A.; in Southeast (Map XI). (Small gives Fla.)

SPECIMENS CITED: LOUISIANA: Orleans, Langlois, April, 1883 (NY); St. Tammany, Arsene 11893 (US). NORTH CAROLINA: Dare, Wells, July 6, 1923 (NCS); New Hanover, Williamson 148 (PH). SOUTH CAROLINA: Horry, Weatherby & Griscom 16598 (DUKE, GH, NY).

30. OXYPOLIS Raf. Dropworts.

Glabrous, erect, branching perennials. Roots fibrous and tuberous. Leaves pinnate, ternate, or reduced to hollow phyllodes. Umbels compound, opposite bract-like leaves or occasionally cymose. Bracts and bractlets simple and narrow or absent. Flowers regular. Calyx-teeth distinct. Petals white, yellowish, or purple, recurved at tips. Stylopodium conic. Ovary laterally flattened, smooth. Fruit dorsally flattened, ribbed. Ribs alike, the laterals closely applied to wings at the commissure. Carpophore split to base. Oil-tubes solitary between ribs, 2 on commissure. Seed dorsally flattened.

Previously the corky wings at the commissure of the fruits were described as a part of the lateral ribs (wings were described as nerved on the dorsal side). The position taken here is that the ribs and wings are distinct and not a single structure. They are believed to be comparable to the corky commissural bands of some species of genera like *Ptilimnium* and *Lilaeopsis*.

Leaves reduced to septate phyllodes.
  Sheaths of lower leaves obviously longer than 1 cm.; body of fruit thicker than thin lateral wings . . . . 1. *O. filiformis*
  Sheaths of all leaves less than 1 cm. long; body of fruit thinner than thick corky wings 2. *O. canbyi*
Leaves with blades.
  Leaves pinnate; veins netted; most leaf blades sessile or nearly so . . . . 3. *O. rigidior*
  Leaves ternate or simpler; veins parallel; leaf blades on distinct petiolules, sometimes longer than blades . . . . 4. *O. ternata*

1. *Oxypolis filiformis* (Walt.) Brit. Water Dropwort.

Plants up to 20 dm. tall; roots fibrous; stems hollow shells; septations of phyllodes with tiny projections in depressions, these representing reduced leaflets; rays 6–15, usually 9–12; pedicels of umbelets 4–21, usually 15–18; bracts and bractlets simple; flowers perfect and staminate, first umbel usually predominantly perfect; petals white; fruits ovoid, obovoid, or ellipsoid.—Native. Flowers in summer and fall.

DISTRIBUTION: Open, wet places; chiefly coastal plain. Fla. to Tex. and Va.; W. I.; in Southeast (Map XIII), all states except Tenn.

SPECIMENS CITED: ALABAMA: Cullman, Mohr, 1887 (US); Mobile, Browne A-43 (NCU). FLORIDA: Alachua, West, Aug. 19, 1927 (FLA); Baker, Murrill,

Sept. 22, 1940 (FLA); Bradford, Murrill, no number or date (FLA); Brevard, Fredholm 5661 (GH); Broward, Small 4434 (NY); Calhoun, West, Sept. 9, 1931 (FLA); Charlotte, Frye, Sept. 3, 1946 (FLA); Clay, Totten, Sept. 7, 1945 (NCU); Collier, Scull, Sept. 1, 1937 (FLA); Dade, Palmer 195 (GH, NY, PH, US); De Soto, West, Sept. 23, 1938 (FLA); Duval, Nash 2596 (GH, NCU, NY, PH, US); Flagler, West & Arnold, Oct. 10, 1940 (FLA); Franklin, Biltmore Herb. 3621b (GH, NY, US); Gadsden, Foster 118 (FLA); Gilchrist, West & Arnold, Oct. 5, 1940 (FLA); Gulf, Small & West, Aug. 8, 1935 (FLA); Hardee, Kirk, Oct. 10, 1942 (FLA); Hendry, Davis, Oct. 8, 1941 (FLA); Highlands, Schallert 891 (FLA); Hillsborough, Emmel & West, Nov. 22, 1949 (FLA); Jackson, Wiegand & Manning 2284 (GH); Lee, Davis, Sept. 13, 1947 (NCS); Leon, Rugel, Aug., 1843 (NY); Liberty, West & Arnold, July 23, 1940 (FLA); Manatee, Tracy 7091 (GH, NY, US); Monroe, Moldenke 363a (DUKE, NY); Okeechobee, Davis, Aug. 21, 1934 (FLA); Orange, O'Neill, Sept. 24, 1929 (US); Osceola, Singeltary, Oct. 10, 1937 (DUKE, NCS); Putnam, West, Sept. 24, 1940 (FLA); Santa Rosa, Curtiss, Nov., 1901 (US); St. Johns, Reynolds, Aug. 1874 (NY); Volusia, Butts, July 21, 1943 (GH); Wakulla, Rugel 285 (US); Walton, Hocking, Aug. 28, 1940 (FLA); Washington, Senner, Aug. 31, 1942 (FLA). GEORGIA: Baker, Ford & Thorne, Aug. 29, 1946 (TENN); Berrien, Harper 659 (GH, NY, US); Chatham, Hopkins 33 (NY); Dooly, Harper 2220 (GH); Emanuel, Harper 993 (GH, NY, US); Lee, Harper 1147 (GH, NY, US). LOUISIANA: Orleans, Drummond (GH); St. Tammany (?), Brown 7184 (GH); Tangipahoa, Correll 10534 (DUKE). MISSISSIPPI: Harrison, Tracy 7015 (GH); Jackson, Seymour 9183170 (GH, NCU); Tishomingo, Rhoades, Sept., 1940 (GH). NORTH CAROLINA: Brunswick, Rodgers 891C (GA, NCU, NY); Columbus, Rodgers 882C (GA, NCU, US); Craven, reported by Croom; Cumberland, Rankin, Aug. 23, 1940 (NCU); New Hanover, Godfrey & Wells 6201 (GH, NCS, US); Pender, Rodgers 871C (DUKE, GA, NCS, NCU, NY, US). SOUTH CAROLINA: Berkeley, Hunt 1072b (CLEMS); Charleston (?), Porcher, no number or date (NY); Georgetown, Godfrey & Tryon 1057 (GH, NY, US); Hampton, Wiegand & Manning 2283 (GH); Orangeburg, Eggleston 5022 (GH, NY). TENNESSEE: None.

2. *Oxypolis canbyi* (C. & R.) Fern.

Plants up to 9 dm. tall; fruit almost orbicular to oblong-ellipsoid, wings thicker than body of fruit.—Native. Flowers in summer and fall.

This plant is smaller than *O. filiformis* which it most closely resembles, and its range extends further north. It is known from only two locations, but is included here because of the possibility of its being found in North Carolina.

DISTRIBUTION: Open, wet places; coastal plain. Known from Ga. (Map XIII) and Del.

SPECIMENS CITED: DELAWARE: Sussex, Canby, Sept. 16, 1891 (US). GEORGIA: Lee, McVaugh 5235 (DUKE).

3. *Oxypolis rigidior* (L.) Raf. (*O. turgida* Small; *O. rigidior* var. *ambigua* [Nutt.] Robins.) Cowbane, Hemlock Dropwort, Water Dropwort, Pig Potato, Water Parsnip.

Plants up to 16 dm. tall; roots usually tuberous toward distal end; leaflets usually 7–11 (3–13), rarely 4 leaflets from same level of rachis, most sessile or subsessile, lanceolate, elliptic, oblong, linear, ovate, and obovate, mostly acute at apex, entire or with large teeth toward distal end or on one side of blade; rays 12–45, very slender; pedicels slender, numerous; petals white; stylopodium green; fruit (Fig. 29) ovoid, ellipsoid, or oblong.—Native. Flowers in summer and fall.

Plants with entire leaves have been described as a variety. That status is not recognized at present (Allard, 1944). There is a tendency for plants growing in the open to have slender, entire leaves; however, entire and toothed leaves have been seen on the same plant.

DISTRIBUTION: Open or semi-open, wet places; mts., pied., or coastal plain. Fla. to Tex., north to N. Y. and Ont. (Macoun, 1901; NY); in Southeast (Map XIII), all states.

SPECIMENS CITED: ALABAMA: Baldwin, Tracy 8632 (GH, NY, US); Jackson, Porter, July 15, 1936 (GH); Jefferson, Vasey, 1897 (NY, PH); Lee, Earle & Baker 1237 (NY); Mobile, Mohr, July, 1875 (US). FLORIDA: Gadsden, Biltmore Herb. 4698 (GH, NY, US). GEORGIA: Clarke, Pyron, Oct. 18, 1929 (DUKE); Coffee, Harper 722 (NY, US); Dade, Cronquist 4827 (FLA, GA, US); Habersham, Small, Aug. 20–Sept. 3, 1894 (NY); Rabun, Duncan 10485 (GA, NCU); Randolph, Harper 1784 (GH, NY, US); Richmond, Cuthbert, Sept. 18, 1907 (FLA). LOUISIANA: Feliciana (East or West ?), Carpenter, 1842 (US); Madison (?), collector unknown, 1846 (PH); Natchitoches, Palmer 8814 (NY); Rapides, Hale, no number or date (PH, US); Webster, Correll 10308 (DUKE). MISSISSIPPI: Jackson, Earle, Oct. 27, 1889 (NY); Wayne, Pollard 1246 (GH, NY, US). NORTH CAROLINA: Alleghany, Rodgers 799C (NCS, NCU); Ashe, Rodgers 805C (NCU); Avery, Rodgers 821C (DUKE, NCU); Bladen, reported by Harper; Brunswick, Godfrey 10102 (NCU); Caldwell, Rodgers 820C (GA, NCU); Clay, Rodgers 611C (NCU); Columbus, Rodgers 885C (NCU, US); Dare, Radford 5083 (NCU); Forsyth, Schallert, Sept. 11, 1941 (NY); Haywood, Rodgers 694C (NCU); Henderson, Rodgers 642C (NCU); Jackson, Rodgers 594C (GA, NCU); Lee, Godfrey 6922 (GH, NCS); Macon, Rodgers 606C (NCU); Mitchell, Rodgers 828C (DUKE, NCU); Nash, Godfrey & Kerr 6657 (DUKE, NCS); New Hanover, reported by Wood & McCarthy; Onslow, Godfrey 6457 (GH, NCS, US); Orange, Schweinitz, no number or date (PH); Pender, Rodgers 873AC (NCU, NY, US); Rowan, Small, Aug. 18–27, 1894 (NY, PH); Rutherford, Rodgers 732C (NCU); Stokes, Godfrey & Fox 48590 (NCS); Swain, Ashe, Sept., 1893 (NCU); Transylvania, Rodgers 632BC (NCU); Wake, Godfrey 6741 (GH), Oct., 1937 (NCS); Watauga, Rodgers 813C (NCU); Yancey, Rodgers 833C (NCU). SOUTH CAROLINA: Aiken, Ravenel, Aug., 1869 (US); Anderson, Davis 7705 (US); Charleston, Blackman, no number or date (PH); Georgetown, Godfrey

8239 (DUKE, NY, TENN); Oconee, House 3064 (NY); Pickens, Rodgers 267 (DUKE). TENNESSEE: Bledsoe, Shanks et al. 3579 (TENN); Blount, Sharp & Underwood 4563 (TENN); Carter, Rydberg 8204 (NY); Chatham, Svenson 283 (GH, PH); Coffee, Svenson 8963 (GH); Grainger, Brown 11C (TENN); Unicoi, Price 989 (DUKE); Wayne, Svenson 4314 (GH).

4. *Oxypolis ternata* (Nutt.) A. Heller Ternate Water Dropwort.

Plants very slender, up to 9 dm. tall; roots tuberous, club-shaped or obovoid; stem mostly less than 2 mm. in diameter, rarely 4 mm.; blades 1, 2, or 3 to a leaf, veins parallel; petioles up to 3.7 dm. long; petiolules distinct, even if only one blade, sometimes as long as blade; umbels mostly 2–4, rarely 8; rays 5–12, long and slender; bracts absent or 1–4 and simple; flowers white with yellowish and rose tint; fruit ellipsoid, obovoid, or ovoid.—Native. Flowers in fall.

This plant is probably more abundant than the few herbarium specimens indicate. It is particularly difficult to locate because its slender, grassy appearance blends with the background of grasses in the savannas. In addition, it makes a sudden appearance in late fall. A fruitless attempt was made to locate it on the big savanna at Burgaw in Sept., 1949, but a week later it was abundantly present almost everywhere. The earliest records of flowers are in September.

DISTRIBUTION: Savannas; coastal plain. Fla. to Va.; Tex. (Cory 49902; GH); in Southeast (Map XIII), Fla., Ga., S. C., and N. C.

SPECIMENS CITED: FLORIDA: Calhoun, Small et al. 11011 (FLA); Franklin, Curtiss 1010 (GH, NCU, PH, US); Liberty, Ford et al., Nov. 11, 1930 (PH). NORTH CAROLINA: Brunswick, Rodgers 888C (DUKE, GA, NCS, NCU, NY, US); Craven, Croom, no date or number (PH); Duplin, Rodgers 877C (DUKE, GA, NCU, NY, US); Harnett, Godfrey 50122 (FLA, NCS, NCU); Pender, Rodgers 892C (NCU). SOUTH CAROLINA: Darlington, Norton, Oct. 30, 1921 (NCU).

31. ANGELICA L. Angelicas.

Large, glaucous, glabrous, or pubescent, branching perennials. Taproots. Leaves mostly 2- or 3-pinnate with all basal leaflets having stalks and each successively higher leaflet with shorter stalk until the leaflets sessile; upper leaves with conspicuously "inflated" petioles, blades reduced or absent. Umbels compound, opposite leaves (sometimes bract-like) or cymose. Bracts absent or 1–3, linear to "inflated"; bractlets present. Flowers tending to be slightly irregular. Calyx-teeth absent or small. Petals white, greenish, pink, or purple; spreading, recurved at tips. Stylopodium large, low-conic. Ovary laterally flattened. Fruit dorsally flattened and ribbed, lateral ribs extended as wings. Carpophore split to base. Oil-tubes 1-several between ribs, 4-several on commissure. Seed dorsally flattened.

Ovaries and fruits pubescent; entire inflorescence covered with dense short pubescence; petals white..1. *A. venenosa*
Ovaries and fruits glabrous; inflorescence essentially glabrous except near attachment of rays and pedicels; flowers greenish..2. *A. triquinata*

1. *Angelica venenosa* (Greenway) Fern. (*A. villosa* [Walt.] B. S. P.) Angelica, Hairy Angelica.

Plants up to 18 dm. tall, practically glabrous except near inflorescence; leaflets thickish, oblong, elliptic, or lanceolate, obtuse or acute at apex, obtuse, acute or oblique at base, serrate or crenate-serrate, sometimes cut to midrib; rays 12–35, usually over 20; umbelets crowded with 25–35 flowers; bractlets 6–7; calyx-teeth distinct; petals with pubescence on under side of veins; fruit oblong to almost orbicular; dorsal and intermediate ribs shallow, lateral ribs deep and forming wings.—Native weed. Flowers from spring to fall.

DISTRIBUTION: Roadsides, abandoned fields, savannas, and woods; mts., pied., and coastal plain. Fla. to Miss. and Ark., north to Mass. and Minn.; in Southeast (Map XIV), all states except La.

SPECIMENS CITED: ALABAMA: Autauga, Mohr, July, 1881 (US); Baldwin, Tracy 8052 (GH, NY, US); Cullman, Mohr, no number or date (US); Jackson, Porter, June 15, 1938 (GH); Lee, Earle & Baker, Aug. 15, 1897 (NY); Macon, Wiegand & Manning 2244 (GH); Tuscaloosa, Harper 3089 (GH, NY, PH). FLORIDA: Jackson, Curtiss, no number or date (GH). LOUISIANA: None. MISSISSIPPI: Wayne, Pollard 1246A (NY, US). NORTH CAROLINA: Alamance, Rodgers 779C (NCU); Alexander, Rodgers 752C (NCU); Alleghany, Rodgers 798C (NCU); Anson, Rodgers 778C (NCU); Avery, Rodgers 825C (NCU); Buncombe, Rodgers 687C (NCU); Burke, Rodgers 723C (NCU); Cabarrus, Rodgers 765C (NCU); Caldwell, Rodgers 840C (NCU); Caswell, Godfrey 5550 (GH); Catawba, Rodgers 750C (NCU); Chatham, Rodgers 484C (NCU); Cherokee, Rodgers 621C (NCU); Clay, Rodgers 610C (NCU); Columbus, Rodgers 886C (NCU); Davie, Rodgers 761C (NCU); Durham, Blomquist 4372 (DUKE); Forsyth, Rodgers 377C (NCU); Gaston, Rodgers 740C (NCU); Graham, Rodgers 626C (NCU); Granville, Rodgers 404C (NCU); Halifax, Rodgers 419C (NCU); Harnett, Rodgers 478C (NCU); Haywood, Rodgers 696C (NCU); Henderson, Rodgers 641C (NCU); Hoke, Rodgers 574C (NCU); Iredell, Rodgers 754C (NCU); Jackson, Rodgers 593C (NCU); Johnston, Rodgers 472C (NCU); Lee, Rodgers 479C (NCU); Lincoln, Rodgers 748C (NCU); Macon, Rodgers 588C (NCU); Madison, Rodgers 688C (NCU); McDowell, Rodgers 715C (NCU); Mecklenburg, Rodgers 746C (NCU); Mitchell, Rodgers 827C (NCU); Moore, Rodgers 466C (NCU); Onslow, Godfrey 6462 (GH, NCU, US); Orange, Rodgers 390C (NCU); Person, Rodgers 396C (NCU); Polk, Rodgers 647C (NCU); Richmond, Rodgers 579C (NCU); Rutherford, Rodgers 670C (NCU); Sampson, Godfrey 5887 (GH); Stanly, Rodgers 450C (NCU); Stokes, Rodgers 785C (NCU); Surry, Rodgers 788C (NCU); Transylvania, Rodgers 599C (NCU); Wake, Rodgers 469C (NCU); Washington, Rodgers 504C (NCU); Watauga, Rodgers 811C (NCU); Wilkes, Rodgers 796C (NCU); Yadkin, Rodgers 842C (NCU); Yancey, Rodgers 831C (NCU). SOUTH CAROLINA: Aiken, Radford 555 (NCU); Anderson, Duncan 9967 (GA, NCU); Berkeley, Ravenel, no number or date (GH); Darlington, Smith 899 (NCU); Greenville, Peattie

1260A (NCU); Lexington, Godfrey & Tryon 1213 (DUKE, GA, PH, TENN, US); Pickens, Rodgers 243 (DUKE); Williamsburg, Godfrey & Tryon 457 (GH, US). TENNESSEE: Bledsoe, Iltis 3401 (TENN); Carroll, Svenson 461 (GH); Carter, Rydberg 8184 (TENN); Cocke, Kearney 705 (NY, US); Coffee, Clebsch 4756 (TENN); Davidson, Svenson & Shaver 9629 (GH); Hamilton, Rhoades, Aug., 1940 (GH); Knox, Ruth, July, 1895 (GH); Roane, Jennison & Anderson, July 14, 1929 (GH); Robertson, Eggert, July 13, 1897 (NY, US); Sevier, Jennison 458 (TENN); Unicoi, Price 964 (DUKE); Union, Morrison, June 21, 1937 (TENN).

2. *Angelica triquinata* Michx. (*A. curtisii* Coult.) Curtis' Angelica, Filmy Angelica.

Plants coarse, up to 18 dm. tall, glaucous or glabrous, with strong odor; leaflets thin, ovate to lanceolate, acuminate at apex, teeth large and acuminate or acute, sometimes cut to midrib; umbels mostly glabrous or faintly hairy, pubescent below attachment of rays and pedicels; rays 10–20; umbelets with 25–50 flowers; bractlets 6–12; calyx-teeth absent; stamens and stylopodium green; fruit ovoid; dorsal and intermediate ribs shallow, lateral ribs extended as wings.—Native. Flowers in summer and fall.

In the summer these plants present a striking appearance near the top of Mt. Mitchell where they are the most conspicuous plants in the extensive open areas.

DISTRIBUTION: Along streams and in open or semi-open places; mts. N. C. and Tenn. to Penn. (also known from boundary between N. C. and Ga. and reported from mts. of S. C.); in Southeast (Map XIV), Ga., N. C., and Tenn.

SPECIMENS CITED: GEORGIA: Thomas Bald on N. C.-Ga. boundary, Small, Aug. 19, 1893; Mts. of Ga., Buckley, no number or date (NY). NORTH CAROLINA: Ashe, Rodgers 806C (NCU); Avery, Rodgers 822C (NCU); Buncombe, Britton, Sept. 18, 1885 (NY); Caldwell, Rodgers 819C (NCU, NY); Clay, Rodgers 612C (NCS, NCU); Graham, Rodgers 622C (DUKE, NCU); Haywood, Rodgers 698C (DUKE, GA, NCU); Macon, Rodgers 603C (NCU, NY); Madison, Rodgers 690C (NCU); Mitchell, Chickering, Aug. 5, 1880 (US); Swain, Harbison & Totten, Sept. 15, 1932 (NCU); Watauga, Rodgers 814C (NCU, US); Yancey, Rodgers 720C (DUKE, GA, NCU, NY, US). SOUTH CAROLINA: Reported by Ives. TENNESSEE: Carter, Britton, Sept. 9, 1895 (NY); Cocke, Kearney 706 (NY); Sevier, Jennison 4683 (TENN).

32. CONIOSELINUM Hoff.

Glabrous, erect, branching perennials. Taproots or clustered fleshy roots. Umbels compound. Bracts absent or several; bractlets with hyaline margins. Calyx-teeth obsolete. Petals white with recurved tips. Styles shorter than petals. Stylopodium conic. Fruits dorsally flattened, ribbed; lateral ribs deepest. Carpophore split almost to base. Oil-tubes 1–4 between ribs, 2–several on commissure. Seed dorsally flattened.

1. *Conioselinum chinense* (L.) B. S. P. Hemlock Parsley.

Plants up to 15 dm. tall, sparingly branched; leaflets pinnatifid with the segments mostly acute; sheaths of upper leaves conspicuously "inflated"; umbels opposite the leaves, rays 9–30; flowers with tendency to irregularity; stamens longer than petals; fruit (Fig. 31) ovoid or oblong-ellipsoid, 4–6 mm. long; dorsal and intermediate ribs acute, about equal, the lateral ribs extended into wings.—Native.

DISTRIBUTION: This plant was collected on Grandfather Mt. by Asa Gray and J. Carey in 1841. No later collections of it are known from there or any other part of the state. This may mean that the station no longer exists. According to records at hand, its distribution is from N. J., Ohio, Mo., and N. Calif., northward through Can. and Alas. into Sib. If it is not found between Penn. and Grandfather Mt., the gap is rather large.

SPECIMEN CITED: NORTH CAROLINA: Caldwell, Gray & Carey, July, 1841 (GH, NY).

33. HERACLEUM L.

Pubescent, tall, coarse biennials or perennials. Taproots or fibrous roots. Leaves pinnate or ternate, blades broad. Umbels compound, opposite leaves or cymose. Bracts absent or few; bractlets simple, numerous. Flowers tending to be irregular. Calyx-teeth obsolete. Petals mostly white, spreading, recurved at tips. Stylopodium conic. Ovary and fruit usually pubescent; fruit strongly dorsally flattened and ribbed, the lateral ribs extended as wings. Carpophore split to base. Oil-tubes solitary between ribs, 2–4 on commissure. Endocarp stony. Seed dorsally flattened.

1. *Heracleum lanatum* Michx. (*H. maximum* Bart.) Cow Parsnip, Masterwort.

Wooly perennials, up to 27 dm. tall; leaves large, ternate; leaflets up to 40 cm. long, ovate to orbicular, cordate at base, coarsely toothed and variously incised; main veins palmate, sheaths of upper leaves greatly "inflated"; rays 6–30; petals with branching veins, outer usually larger and often 2-cleft; ovary wooly; fruit (Fig. 32) obovate to obcordate, 8–13 mm. long; dorsal and intermediate ribs filiform; oil-tubes easily visible on outside, extending about ½ distance from apex.—Native. Occasionally planted as ornamental. Flowers in summer.

DISTRIBUTION: Waste-places and fields; mts. of this region. N. C. to Ariz. and Calif., north to Can. and Alas.; Siberia; in Southeast (Map IV), N. C. and Tenn. (reported from Ga.)

SPECIMENS CITED: GEORGIA: Reported by Mathias & Constance & Small. NORTH CAROLINA: Haywood, Blomquist 4398 (DUKE); Jackson, Oosting 3688 (DUKE); Mitchell, Merriam, Sept. 1, 1892 (US). TENNESSEE: Cocke, Kearney 707 (NCU, NY, US).

34. PASTINACA L.

Glabrous or pubescent, coarse biennials and perennials. Fleshy taproots. Stems sharply angular. Leaves pinnate or bipinnate to simple bract-like above. Upper leaves with conspicuous "inflated" sheaths and reduced blades. Umbels large, compound, opposite leaves or cymose. Bracts and bractlets absent or few and simple. Flowers regular. Calyx-teeth obsolete. Petals yellow (or red), spreading, recurved at tips. Stylopodium broad, conic. Ovary and fruit dorsally flattened. Fruit ribbed, the lateral ribs extended as wings. Carpophore split to base. Oil-tubes usually solitary between ribs, 2–4 on commissure. Seed dorsally flattened.

1. *Pastinaca sativa* L. Parsnip, Wild Parsnip, Madnep, Tank, Hart's Eye.

Plants biennial, up to 18 dm. tall; leaflets ovate to oblong, serrate, often variously cut, obtuse or acute at apexes, mostly sessile or subsessile; rays 7–30; styles short; fruit (Fig. 33) 5–6 mm. long, mostly obovate or suborbicular, dorsal and intermediate ribs filiform, alike. Introduced food plant. Flowers in summer.

DISTRIBUTION: Waste-places throughout most of U. S., but seldom seen in Southeast (Map IV).

SPECIMENS CITED: NORTH CAROLINA: Ashe, collector and date unknown (NCU); Avery, Totten, July 1, 1941 (NCU); Haywood, Rodgers 697C (NCU); Henderson, Rodgers 676C (GA, NCU); Jackson, Rodgers 633C (NCU); Polk, Peattie 801A (NCU); Yancey, Radford 2588 (NCU). SOUTH CAROLINA: Reported by Coulter & Ives.

SUMMARY

1. A survey of the Umbelliferae in North Carolina indicates the presence of 34 genera, 59 species, and 4 varieties. Of this total, 44 species and 2 varieties are native, and 15 species and 2 varieties are introduced.

2. Ranges of the following species have been extended beyond that given in Gray's *Manual of Botany* (8th ed.), Small's *Manual of the Southeastern Flora* (1933), and Mathias and Constance's monograph of the Umbelliferae in *N. A. Flora* (1944–1945): *Aegopodium podagraria* var. *variegatum*, *Angelica triquinata*, *Carum carvi*, *Chaerophyllum procumbens*, *Cicuta maculata*, *Daucus pusillus*, *Eryngium prostratum*, *Hydrocotyle sibthorpioides*, *Lilaeopsis chinensis*, *Oxypolis rigidior*, *Oxypolis ternata*, *Sanicula canadensis*, *Sanicula smallii*, *Sanicula trifoliata*, *Sium suave*, *Spermolepis divaricata*, *Taenidia integerrima*, and *Thaspium trifoliatum* var. *flavum*.

3. The following species are either new to the state or are rediscoveries of plants not collected in recent years: *Aegopodium podagraria* var. *variegatum*, *Carum carvi* (reported by Hyams, 1899), *Conium maculatum* (no previous collections known from N. C., but reported throughout U. S. by Mathias & Constance), *Daucus pusillus* (reported by Hyams, 1899), *Lilaeopsis carolinensis* (collected by Wells in 1923; previous collections in 1911 or earlier), *Sanicula trifoliata*,

Torilis japonica, and *Torilis nodosa* (reported by Hyams, 1899; rediscovered by Blomquist and Batson; to be published by Godfrey, Fox, and Blomquist in Rhodora).

4. The distribution of North Carolina species and varieties throughout the Southeast is mapped from collections made in the field in North Carolina plus collections deposited in a number of herbaria.

5. Illustrations of fruit characters of every genus except one are included.

6. The key is constructed in such a way that it is possible to identify to the genus and, in almost every case, to the species or variety whether the plant is in flower or in fruit.

7. The genera, species, and varieties are described and their habitats given.

8. Observations on the possible relationships of several genera are made.

9. Taxonomic criteria generally used as well as possible new criteria are evaluated.

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The distribution maps are based on the outline map published by the McKinley Publishing Company of Philadelphia and used by permission.

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PLATE 13

Surface view and cross sections of fruits of the following species:
FIG. 1. *Hydrocotyle umbellata*
FIG. 2. *Centella erecta*
FIG. 3. *Eryngium yuccifolium*
FIG. 4. *Sanicula canadensis*
FIG. 5. *Daucus carota*
FIG. 6. *Torilis japonica*
FIG. 7. *Scandix pecten-veneris*
FIG. 8. *Osmorhiza longistylis*
FIG. 9. *Chaerophyllum tainturieri*
FIG. 10. *Cryptotaenia canadensis*
FIG. 11. *Coriandrum sativum*
FIG. 12. *Conium maculatum*
FIG. 13. *Erigenia bulbosa*
FIG. 14. *Foeniculum vulgare*
FIG. 15. *Petroselinum crispum*
FIG. 16. *Bupleurum rotundifolium*
FIG. 17. *Taenidia integerrima*
FIG. 18 *Thaspium barbinode*

PLATE 14

Surface view and cross sections of fruits of the following species:
FIG. 19. *Zizia aptera*
FIG. 20. *Carum carvi*
FIG. 21. *Ligusticum canadense*
FIG. 22. *Spermolepis divaricata*
FIG. 23. *Apium graveolens*
FIG. 24. *Ammi visnaga*
FIG. 25. *Sium suave*
FIG. 26. *Cicuta maculata*
FIG. 27. *Ptilimnium capillaceum*
FIG 28. *Lilaeopsis chinensis*
FIG. 29. *Oxypolis rigidior*
FIG. 30. *Angelica venenosa*
FIG. 31. *Conioselinum chinense*
FIG. 32. *Heracleum lanatum*
FIG. 33. *Pastinaca sativa*

PLATE 13

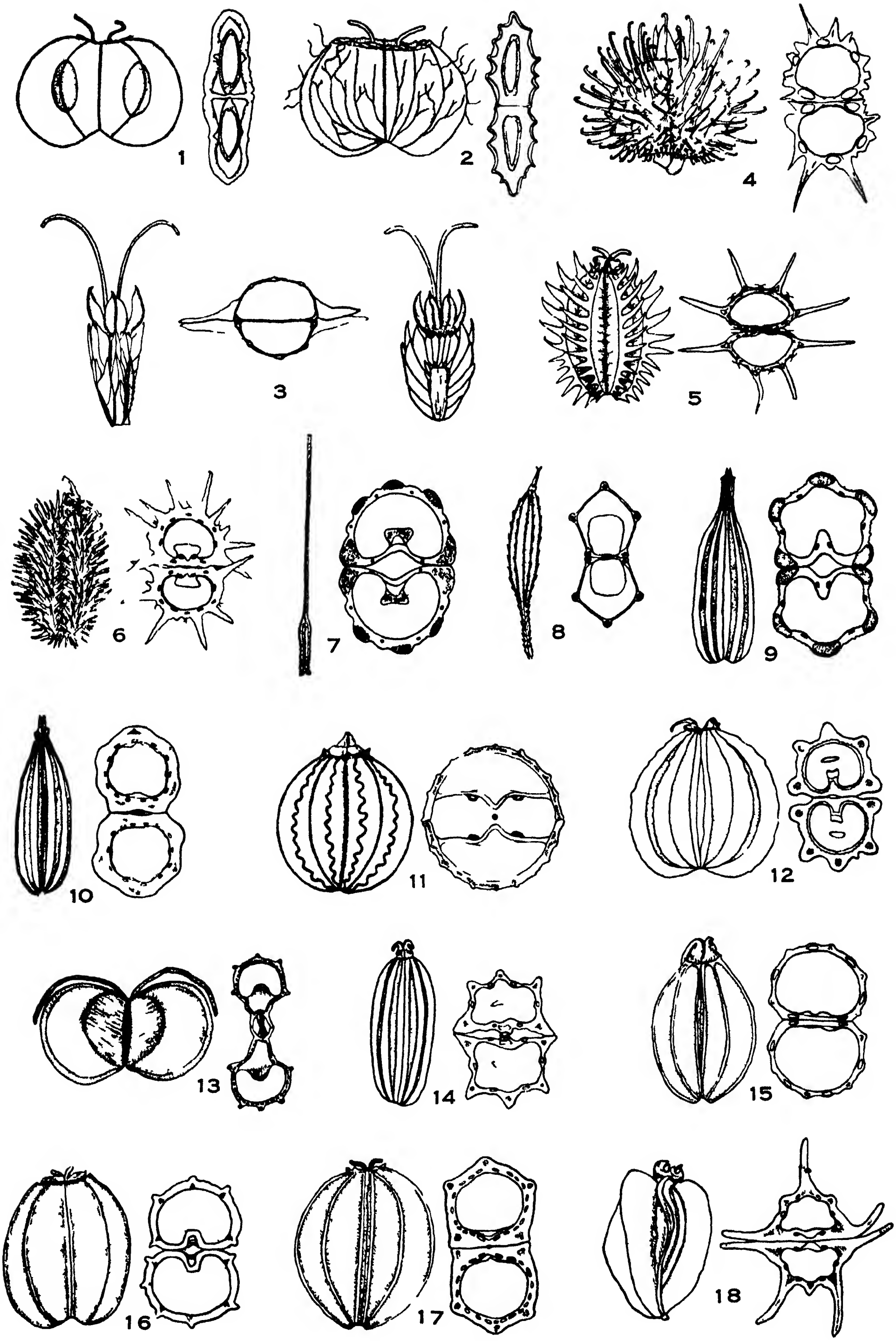


PLATE 14

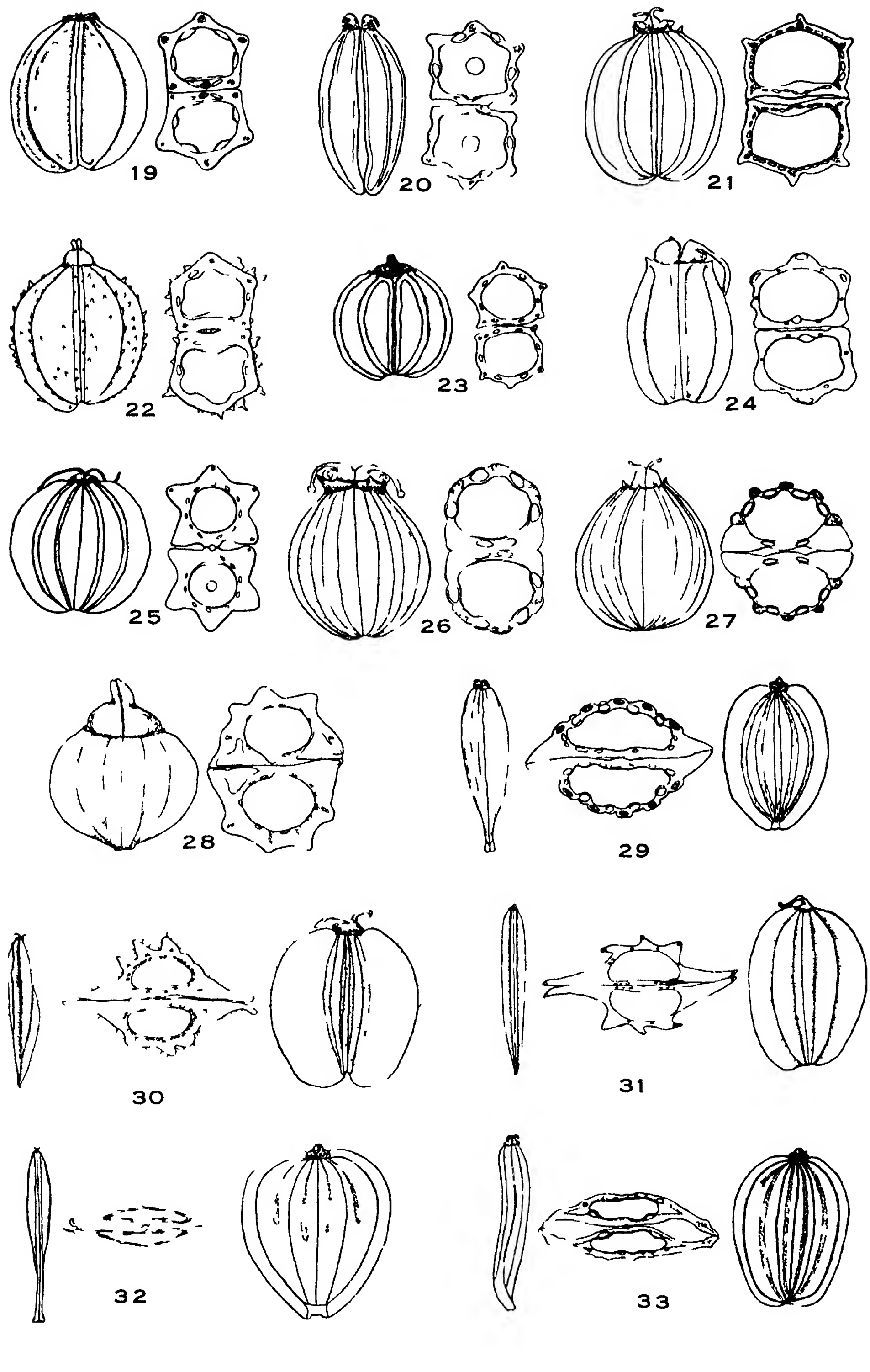
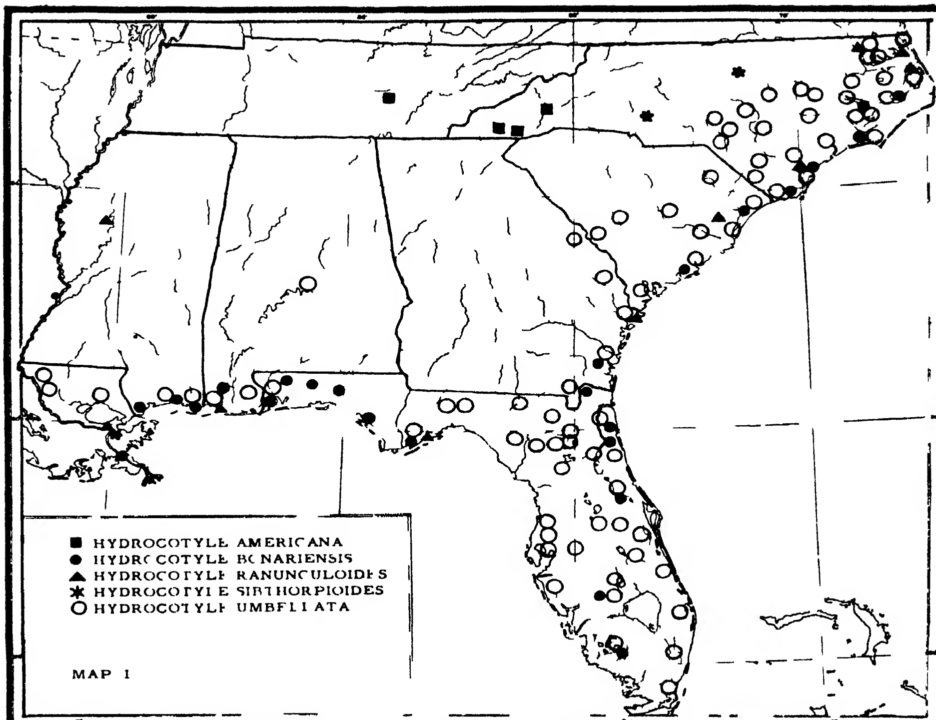


PLATE 15


HYDROCOTYLE AMERICANA
HYDROCOTYLE BONARIENSIS
HYDROCOTYLE RANUNCULOIDES
HYDROCOTYLE SIBTHORPIOIDES
HYDROCOTYLE UMBELLATA
MAP I

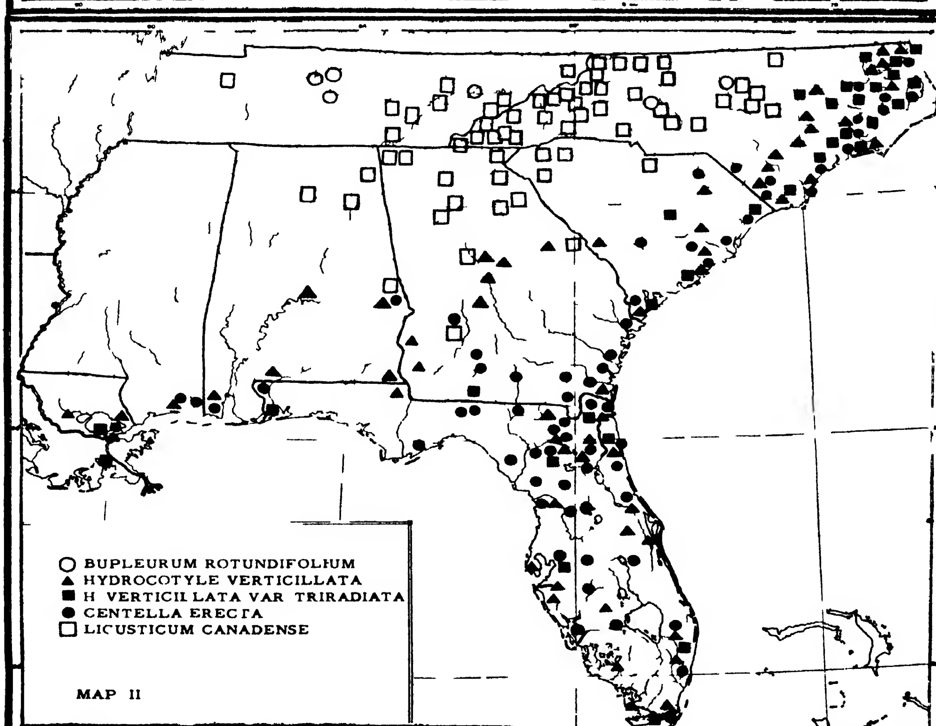
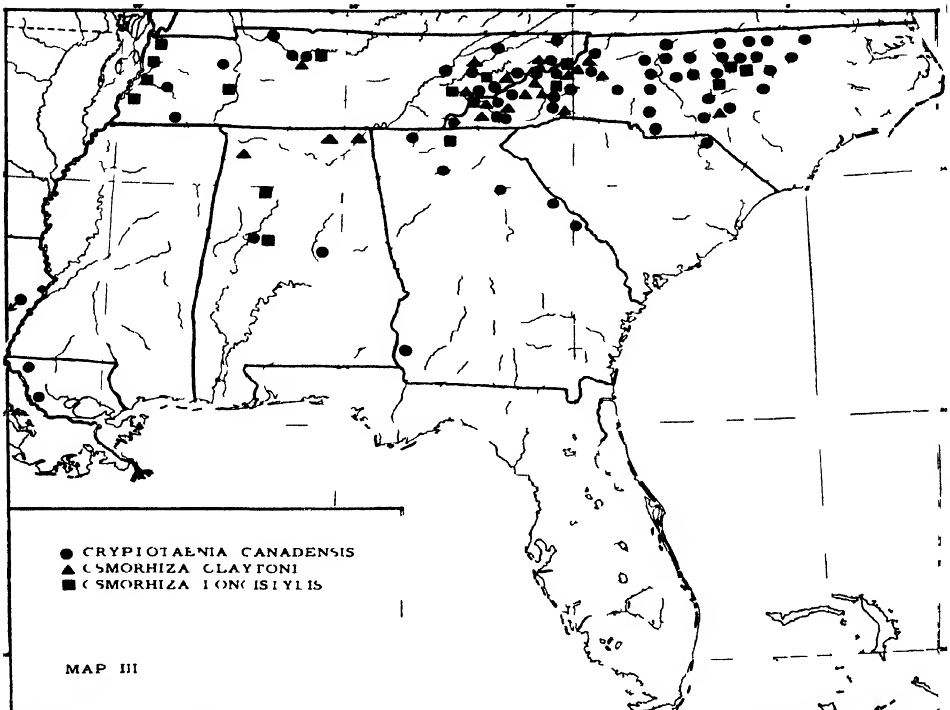

BUPLEURUM ROTUNDIFOLIUM
HYDROCOTYLE VERTICILLATA
H VERTICILLATA VAR TRIRADIATA
CENTELLA ERECTA
LIGUSTICUM CANADENSE
MAP II

PLATE 16


CRYPTOTAENIA CANADENSIS
OSMORHIZA CLAYTONI
OSMORHIZA LONGISTYLIS
MAP III

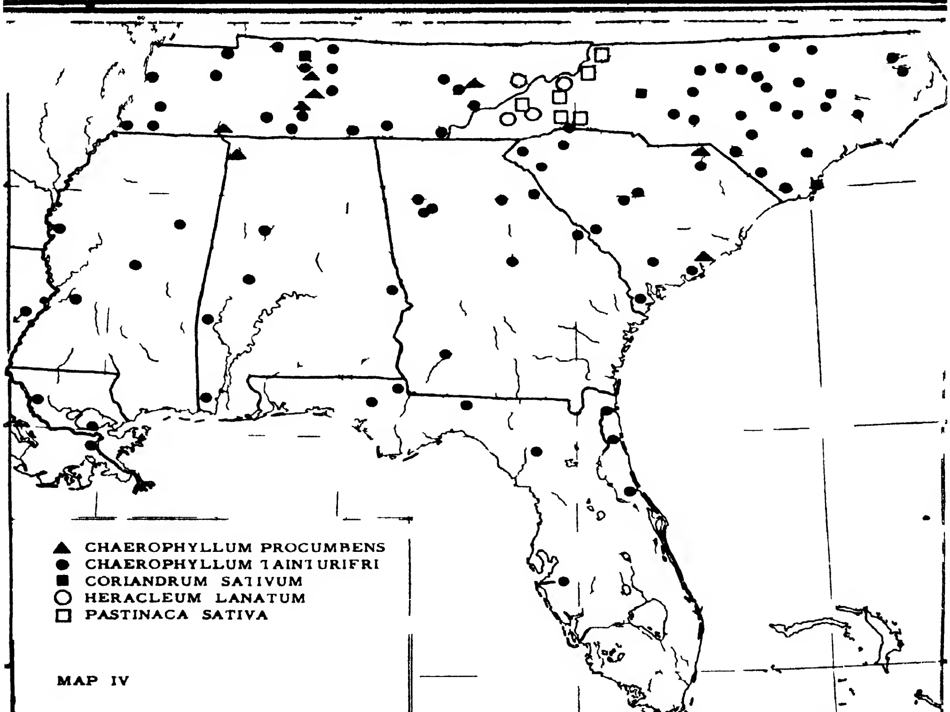
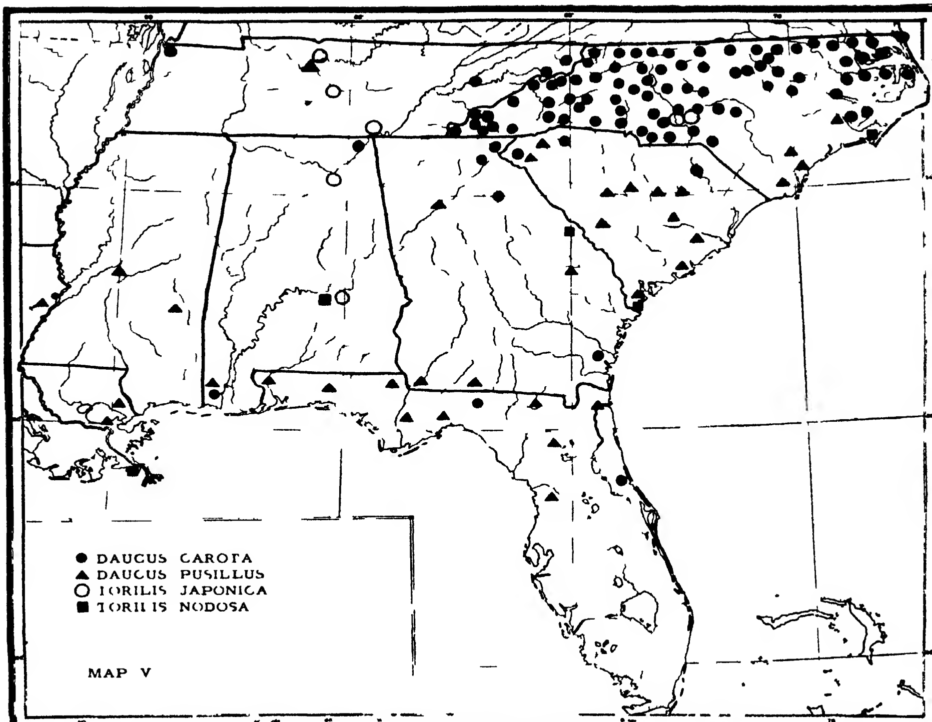

CHAEROPHYLLUM PROCUMBENS
CHAEROPHYLLUM TAINTURIERI
CORIANDRUM SATIVUM
HERACLEUM LANATUM
PASTINACA SATIVA
MAP IV

PLATE 17


● DAUCUS CAROTA
▲ DAUCUS PUSILLUS
○ TORILIS JAPONICA
■ TORILIS NODOSA
MAP V

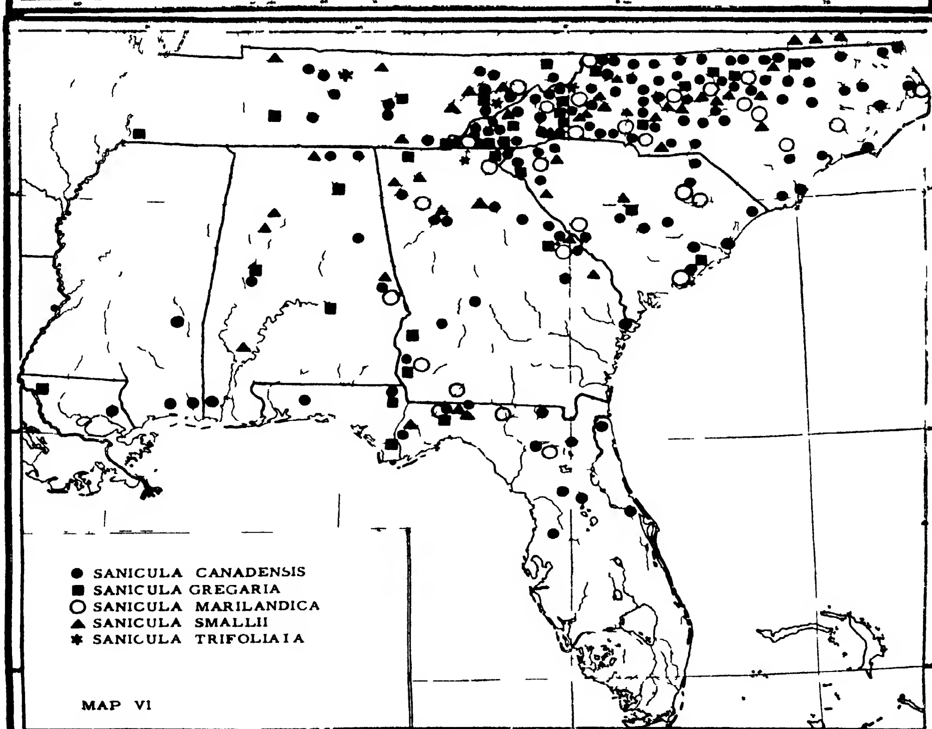
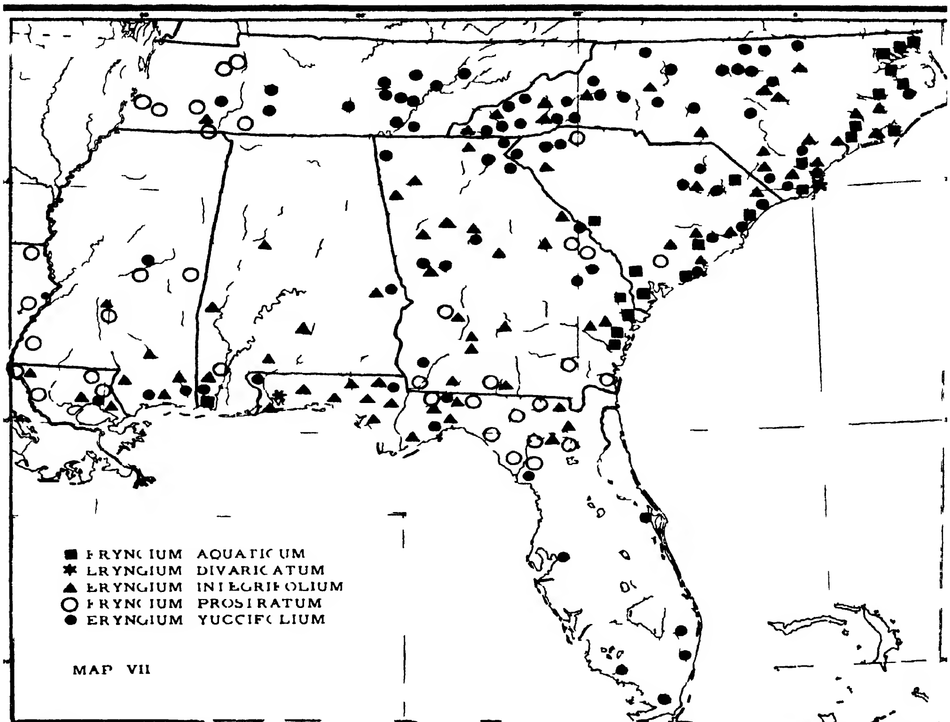

● SANICULA CANADENSIS
■ SANICULA GREGARIA
○ SANICULA MARILANDICA
▲ SANICULA SMALLII
✱ SANICULA TRIFOLIATA
MAP VI

PLATE 18


ERYNGIUM AQUATICUM
ERYNGIUM DIVARICATUM
ERYNGIUM INTEGRIFOLIUM
ERYNGIUM PROSTRATUM
ERYNGIUM YUCCIFOLIUM
MAP VII

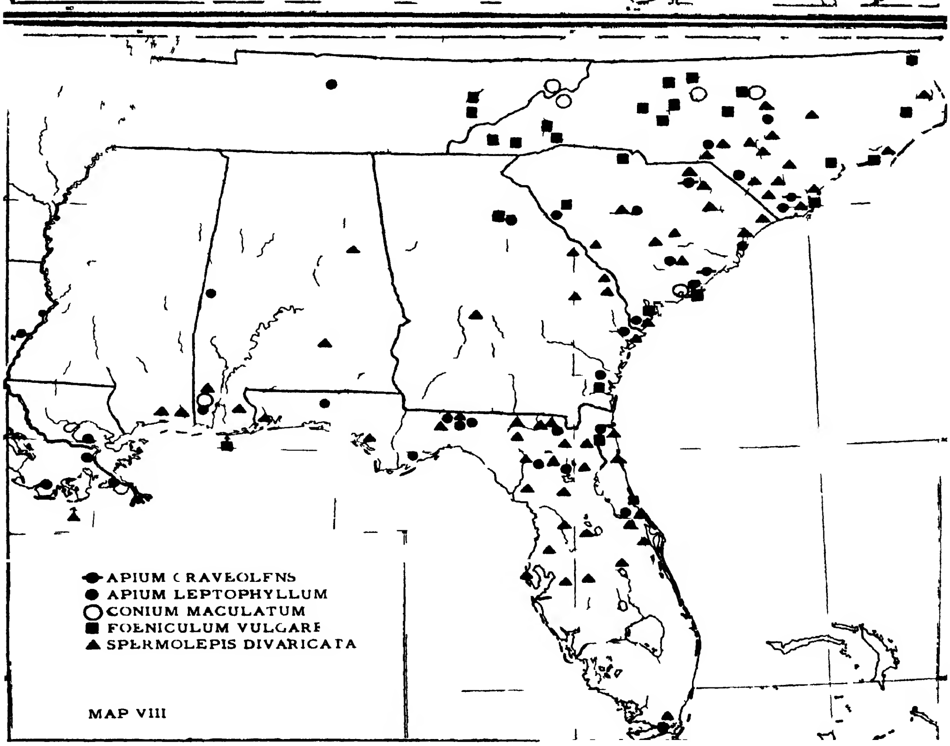
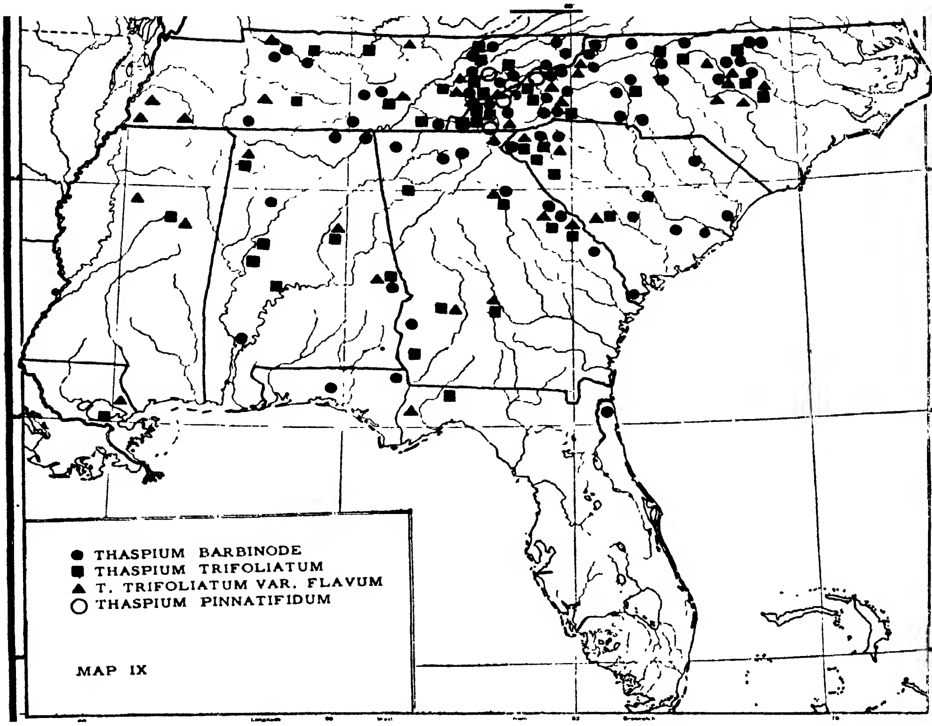

APIUM GRAVEOLENS
APIUM LEPTOPHYLLUM
CONIUM MACULATUM
FOENICULUM VULGARE
SPERMOLEPIS DIVARICATA
MAP VIII

PLATE 19


THASPIUM BARBINODE
THASPIUM TRIFOLIATUM
T. TRIFOLIATUM VAR. FLAVUM
THASPIUM PINNATIFIDUM
MAP IX

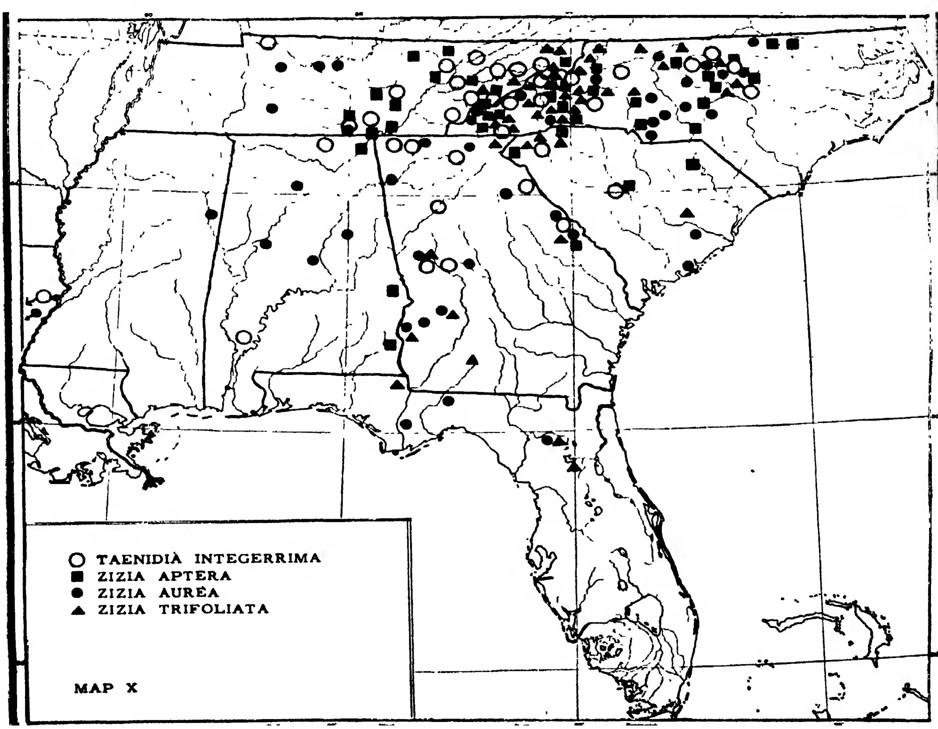
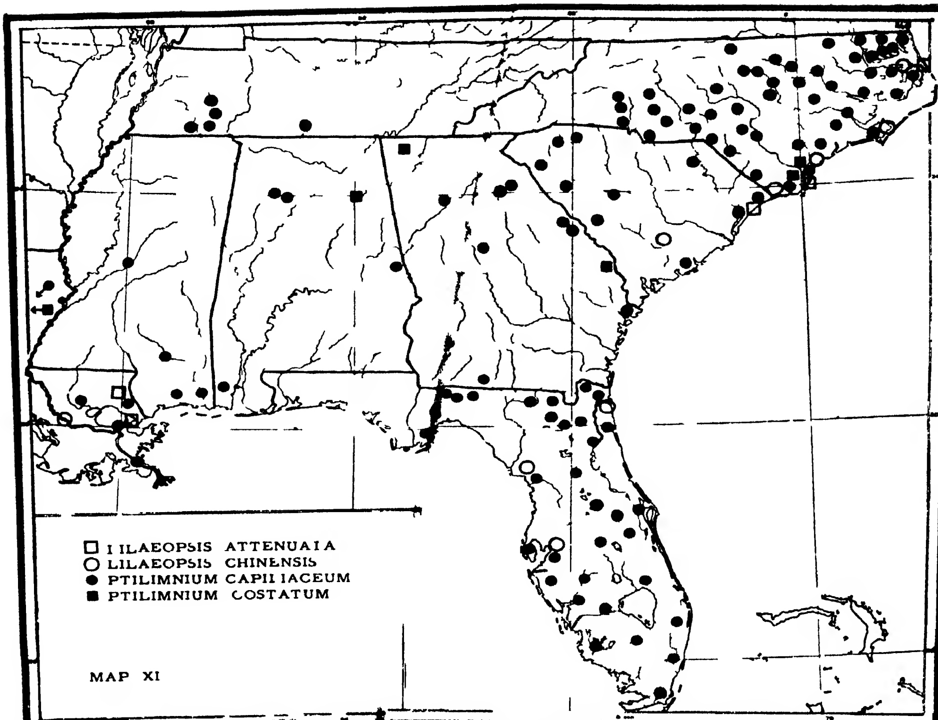

TAENIDIÀ INTEGERRIMA
ZIZIA APTERA
ZIZIA AURÉA
ZIZIA TRIFOLIATA
MAP X

PLATE 20


I ILAEOPSIS ATTENUAIA
LILAEOPSIS CHINENSIS
PTILIMNIUM CAPII IACEUM
PTILIMNIUM COSTATUM
MAP XI

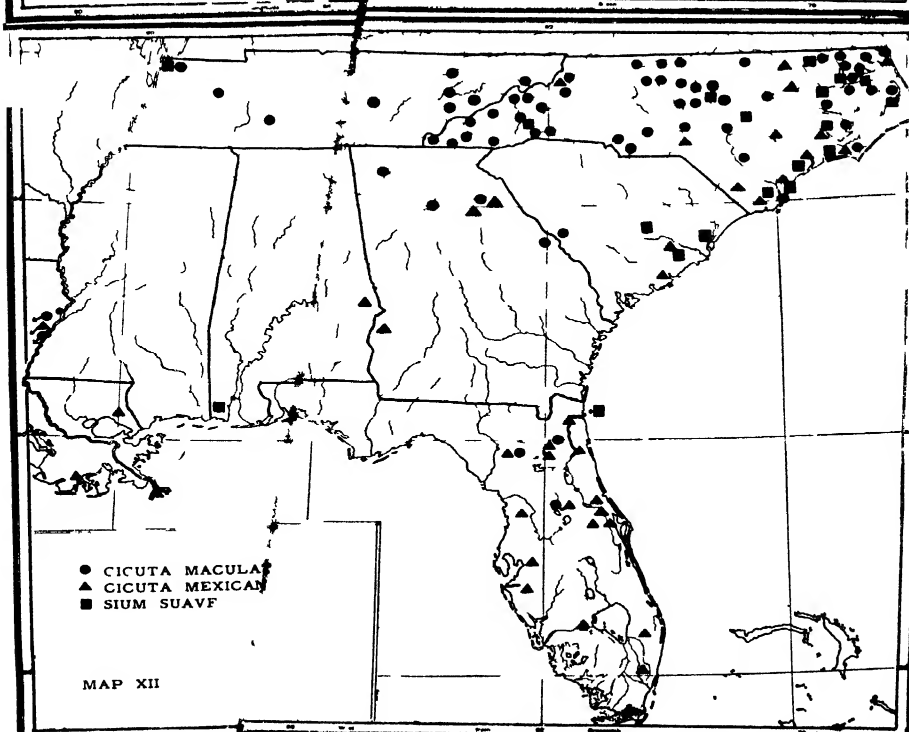
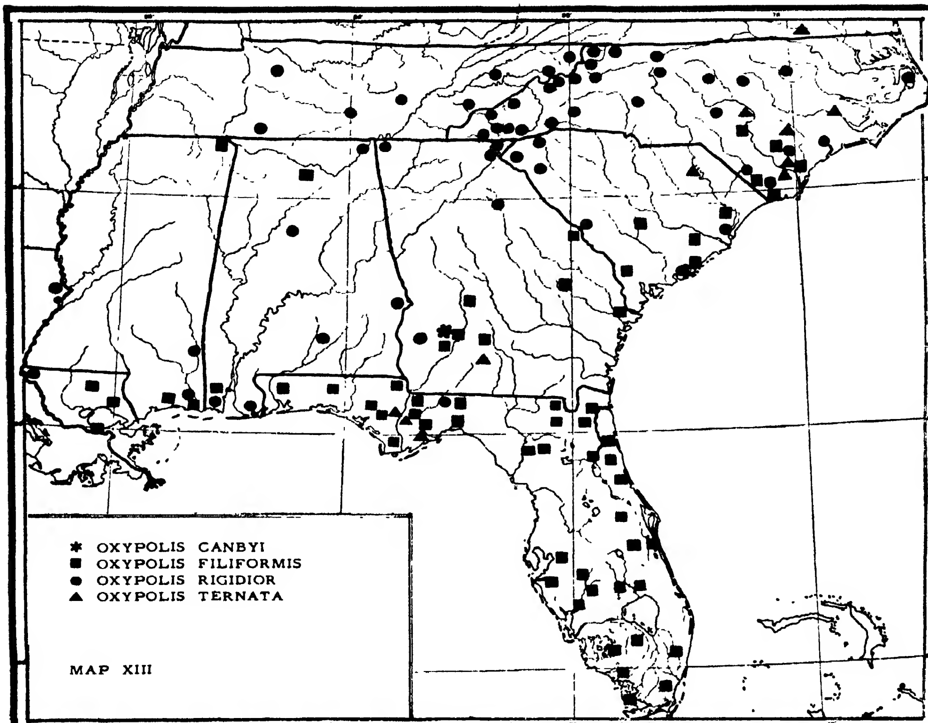
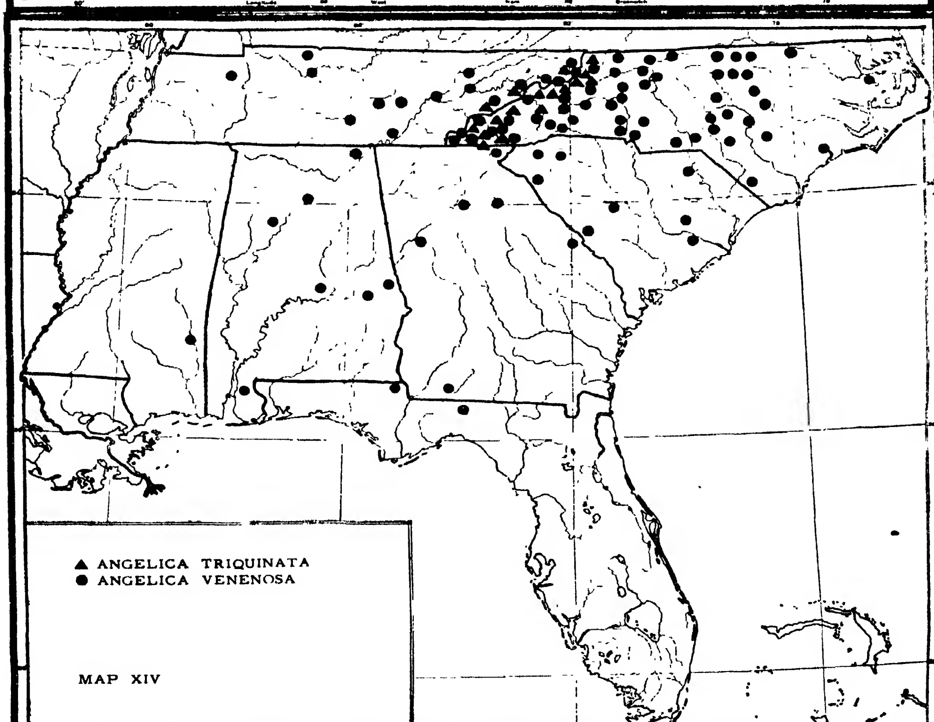

CICUTA MACULA
CICUTA MEXICAN
SIUM SUAVF
MAP XII

PLATE 21



✱ OXYPOLIS CANBYI
■ OXYPOLIS FILIFORMIS
● OXYPOLIS RIGIDIOR
▲ OXYPOLIS TERNATA
MAP XIII



▲ ANGELICA TRIQUINATA
● ANGELICA VENENOSA
MAP XIV